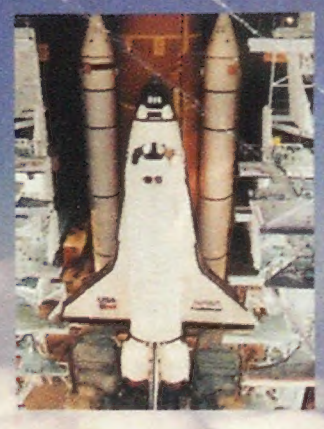
ABORT! How They Stop a Shuttle Launch



AIR&SPACE

Smithsonian•January 1996

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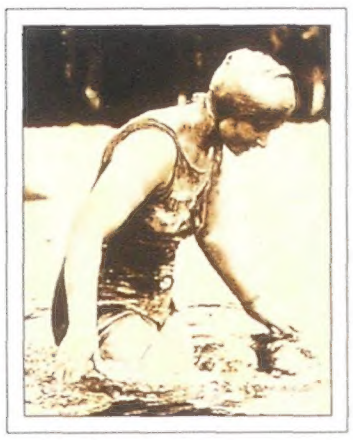
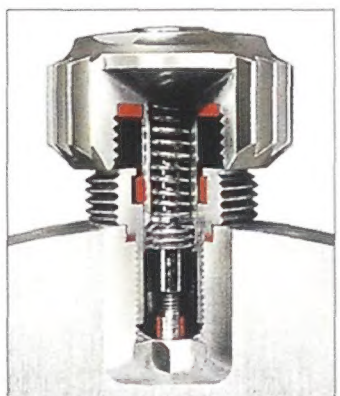
A History of

The history of the Rolex Oyster has been closely allied not only with watchmaking achievements but also with some of history's greatest human accomplishments. Wherever and whenever people have tested the best in themselves, pushed the edge of the envelope, the limits of speed and endurance, Rolex is likely to have been with them. And what makes Rolex so remarkably dependable today is that just as those who have constantly sought to improve their performance, so have we.

1914: Just ten years after the founding of the company, Rolex is certified as the first wristwatch to outperform the pocketwatch by the Kew Observatory.



1926: Rolex invented the rugged Oyster case and the screw-down winding crown, developed on the same principle as the submarine hatch. The reliability of the Oyster was proven when, in 1927, Mercedes Gleitze swam the English Channel in 15 hours and 15 minutes. Her Rolex Oyster successfully timed her swim.

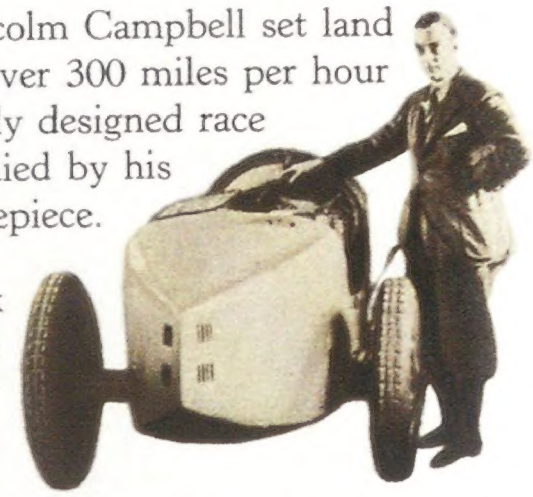


The Twinlock winding crown.

The screw-down winding crown that was created in 1926 has evolved over the years into what is known today as the Twinlock winding crown, pressure-proof to 330 feet. The Triplock winding crown is pressure-proof to 1,000 feet on the Submariner and 4,000 feet on the Sea-Dweller.

1931: Rolex continued to improve its mechanical timepieces, perfecting and patenting the self-winding wristwatch. This was made possible by the invention of the first perpetual rotor automatic mechanism, the Rolex Oyster Perpetual.

1935: Sir Malcolm Campbell set land speed records of over 300 miles per hour in his specially designed race cars, accompanied by his Rolex timepiece.



1945: Rolex created the Datejust, the first pressure-proof, automatic wristwatch chronometer that showed the date in small "window" on the face of the watch

1947: World War II flying ace Chuck Yeager, wearing his Rolex Oyster Perpetual, breaks the sound barrier. Yeager was only 24 years old at the time.

1953: Edmund Hillary and Tenzing Norgay are the first to conquer Mt. Everest. Th expedition's teamwork was synchronized on Rolex timepieces. Rolex created the first pressure-proof, automatic timepiece, the Oyster Perpetual Submariner, certified to 300 feet. Today's Submariner runs even deeper, and is certified to 1,000 feet.

1960: Dr. Jacques Piccard breaks the world record with a 35,000-foot deep-sea dive in the Pacific Ocean with a Rolex Oyster strapped to his bathyscaphe. This historic watch resisted over a ton of pressure per square inch.

1971: Rolex creates the Sea-Dweller, the first diving watch in the world with a helium escape valve that allows the expanding gases within the case to be released during the diver's ascent to prevent explosive decompression of the watch.

Performance.

The Wahiba Sands Expedition in the Sahara.

1986: The Royal Geographical Society scientists studying Wahiba Sands in the Sahara rely on Oyster timepieces to withstand desert sand and extremes of temperature.

1994: With his third win at Le Mans and his tenth endurance championship, Hurley Haywood breaks his own record set in 1991 as the race car driver with the most endurance wins.

Yesterday becomes today.

Steve Wand at the controls of the Concorde simulator.

Since its founding, Rolex has continued to set extraordinarily high standards for all of its timepieces. They have been improved internally hundreds of times. Yet the GMT-Master II, worn today by Concorde pilot Steve Wand, looks, to the untutored eye, remarkably like the Rolex Oyster worn for over 25 years by Brian Trubshaw, who wore his as a Concorde test pilot in 1969.

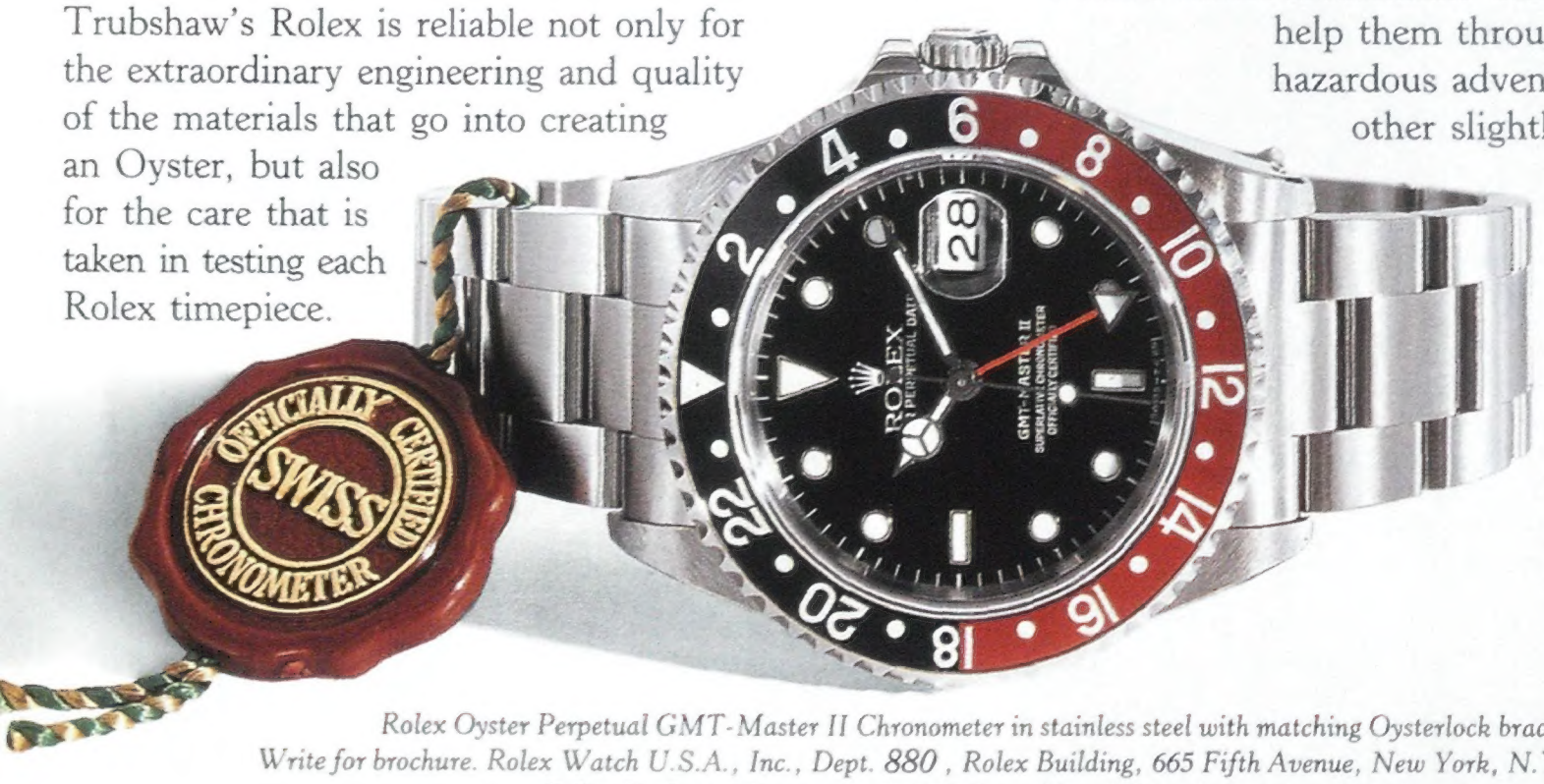
Trubshaw's Rolex is reliable not only for the extraordinary engineering and quality of the materials that go into creating an Oyster, but also for the care that is taken in testing each Rolex timepiece.

First, each Rolex Oyster is rigorously tested at Rolex, then sent to an independent Swiss Institute, the Contrôle Officiel Suisse des Chronomètres. There, each watch must successfully undergo fifteen days and nights of additional testing before it is awarded the prestigious red seal that signifies it is an Official Swiss Chronometer.

This painstaking process helps to explain why so many people today continue to count on the reliability and durability of Rolex. From conservationists like Dr. George Schaller working

Robert Anderson, making the first successful ascent of the west face, reaches the peak of Vinson Massif, Antarctica, via Rolex Ridge.

on the Chang Tang in Tibet to scientific teams crossing the Kimberley range in Australia. From divers like George Bass timing their ascents from the depths off Turkey to climbers like Robert Anderson challenging the heights of the world's tallest mountains. They rely on Rolex to help them through their often very hazardous adventures. As do many other slightly less-adventurous souls all over the world.



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December 1995/January 1996
Volume 10, Number 5

AIR&SPACE

Smithsonian

44

68

CONTENTS

78

28

Cover:
Computer illustrator David Peters digitally manipulated and colorized two photos of Molt Taylor's Aerocar to create this flying fantasy.

Departments

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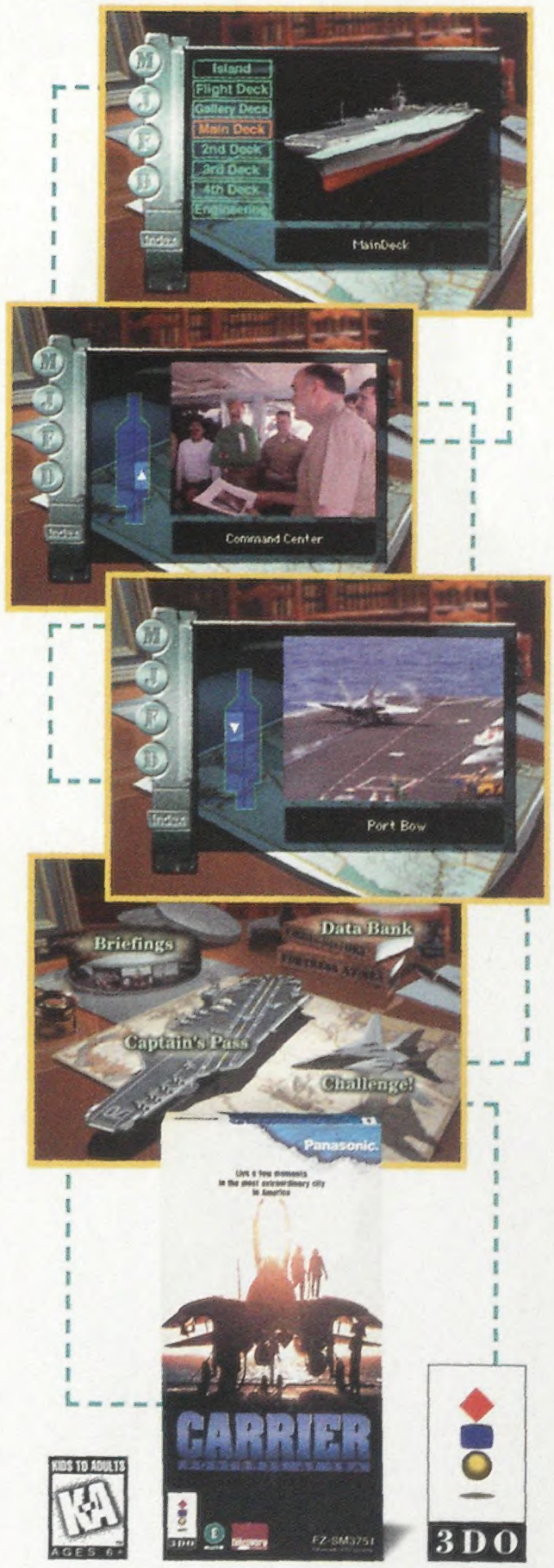

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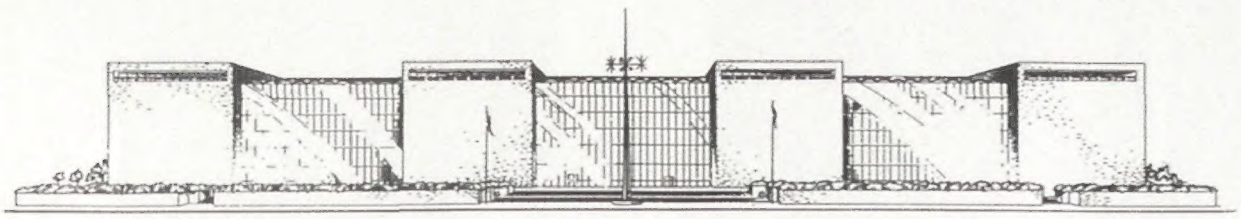

Forces of Argument

A lot of people are worried that the world is splintering along racial, religious, and economic lines. An initial euphoria when the rivalry between the major superpowers ended has given way to the gloomy realization that as the East-West polarity has vanished, so have the political force lines that created a semblance of world order. The "new world order" looks like nothing more than a global shambles as nations and even continents come apart at the seams.

As proof that the aerospace community has its own deep divisions, we offer, in this issue, two ardent agendas so opposed that only one of them could leave the ring on its feet. In one corner, Bruce D. Berkowitz, this issue's Commentary author, argues that huge, lumbering bureaucracies and large projects are inevitable bedfellows, and further, that big, deep-rooted science prevents breakthroughs by absorbing too much of our resources. In the other corner, Frank P. Davidson uses From the Field to propose building tube trains that would create supersonic transportation links connecting commercial centers. More than big science, that's big engineering—and big bucks.

Funny, but you can see the reason in both views, which ought to suggest they could co-exist. On the one hand, Berkowitz is right to point out that the shuttle, for example, is a machine frozen in time. Its basic configuration emerged from a NASA study that began in 1965 as a four-phase "paper" spaceplane. By 1969, lacking neither vision nor courage, NASA had even stipulated six primary missions for the new craft, including support of an orbiting space station. And the shuttle's technology is mostly 1970s stuff, though many of its systems have been updated. In the end, NASA came up short of funds. It had to sit down with the Pentagon and configure the shuttle to handle secret Air Force payloads in return for political support. (If you wonder why the shuttle looks the way it does, that's why.) Now, Berkowitz argues, we have a 30-year-old machine and mission absorbing money that should be spent seeding legions of small research teams that could make major breakthroughs in not only the machines but the mission as well.

Davidson's proposal looks as massive, even on paper, as the great pyramids, the Hoover Dam, and New York City's new underground aqueduct rolled into one. And he certainly has no aversion to venerable technology. In fact he argues convincingly that old stuff can be combined in imaginative ways to make something new: Pull the wheels off some subway trains (or the wings off airplanes), add magnets and a humongous vacuum pump, and *voila!*—a global network of supersonic railroads. If anything, the mixing of established technologies seems to suggest that we should be ashamed of ourselves for having failed to start construction on supersonic rail years ago when Robert Goddard first suggested it. Building the future according to Davidson's blueprint begins to look like a comparatively easy task, especially against the certain political agonies of trying to develop a supersonic airliner. The bureaucracy behind a network of tube trains would almost certainly dwarf that of any project in history, but Davidson would argue that the benefits to commerce will outweigh such concerns. It'll have to be built eventually, Davidson seems to say, so let's get on with it.

Both Berkowitz and Davidson are really urging us toward the same end: the embrace of risk. Berkowitz wants to cancel big, safe bets and roll the dice with research; Davidson says we're too afraid of big projects and investing on a global scale. They differ as to where we ought to go and how we ought to get there, but they agree we shouldn't just sit here. It's a quarrel that calls to mind the differences in style between the Wrights and Samuel Langley—the intuitive bicycle mechanics versus the establishment scientist. It's true that the best ideas can have humble beginnings, but when inventors want to take a new idea to the marketplace they usually have to talk to a bank.

—George C. Larson

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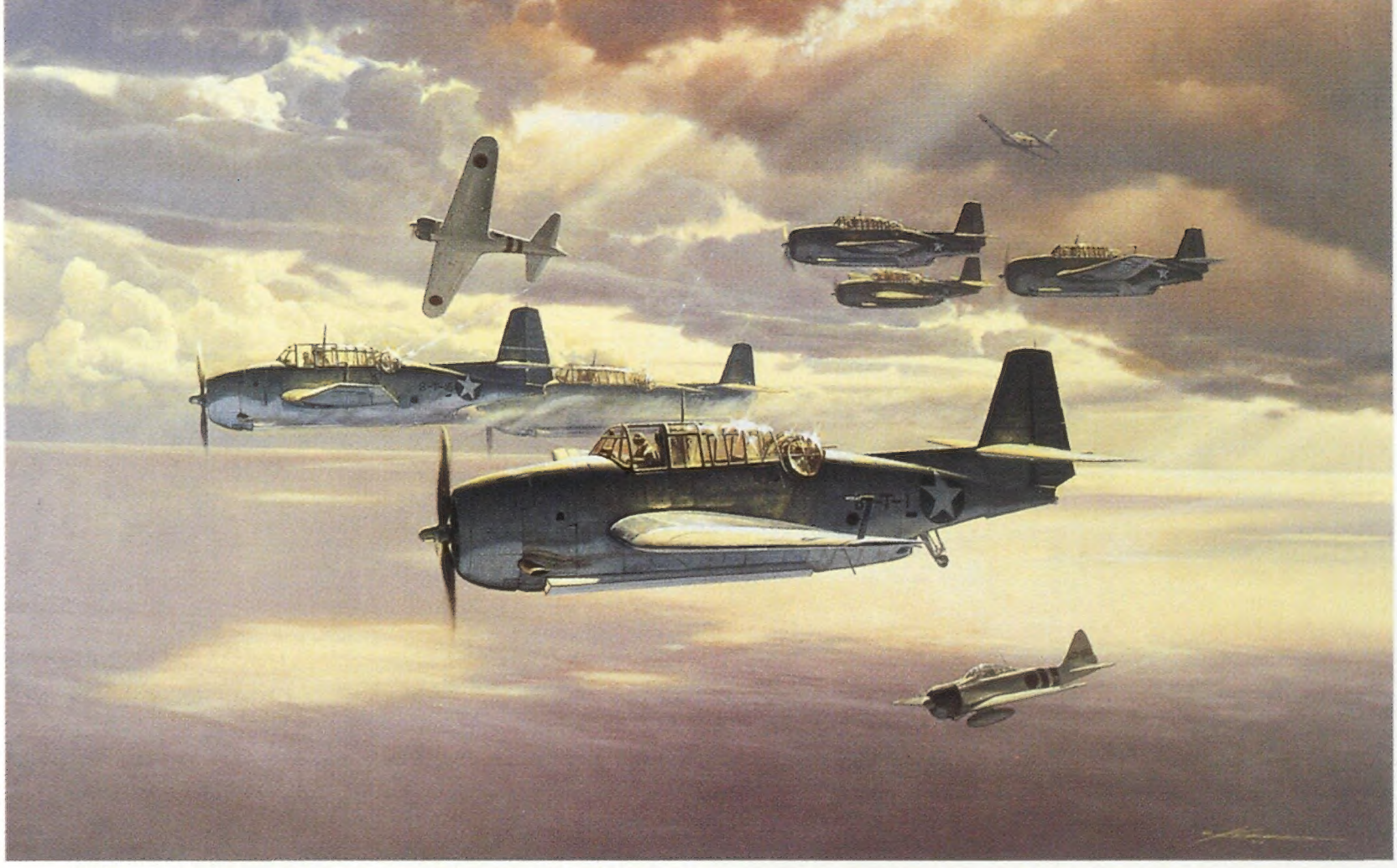

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A.M. Sortie. (right) Commemorating the P-38 Lightning. Countersigned by Anthony W. LeVier,
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LETTERS

The Plight of Lost Airmen

"Homecoming" (Oct./Nov. 1995) illustrates that when it comes to investigating the fate of POWs, MIAs, and aircraft lost in combat, our military learned no lessons from World War II.

As your article shows, the Air Force has retained complete aircraft records kept during that war, so aircraft and aircrew can still be identified from the serial numbers of weapons and engines. However, the Air Force did not retain complete records for aircraft lost in combat during the Korean and Vietnam wars. If you are interested in such an aircraft, all the U.S. Air Force Historical Research Center at Maxwell Air Force Base can give you are the date it was delivered, the units it was assigned to, and the date it was lost.

Though retaining complete aircraft records would not have solved every question about the POWs and MIAs of the Vietnam war, it would have prevented a lot of anguish and saved untold man-hours and dollars.

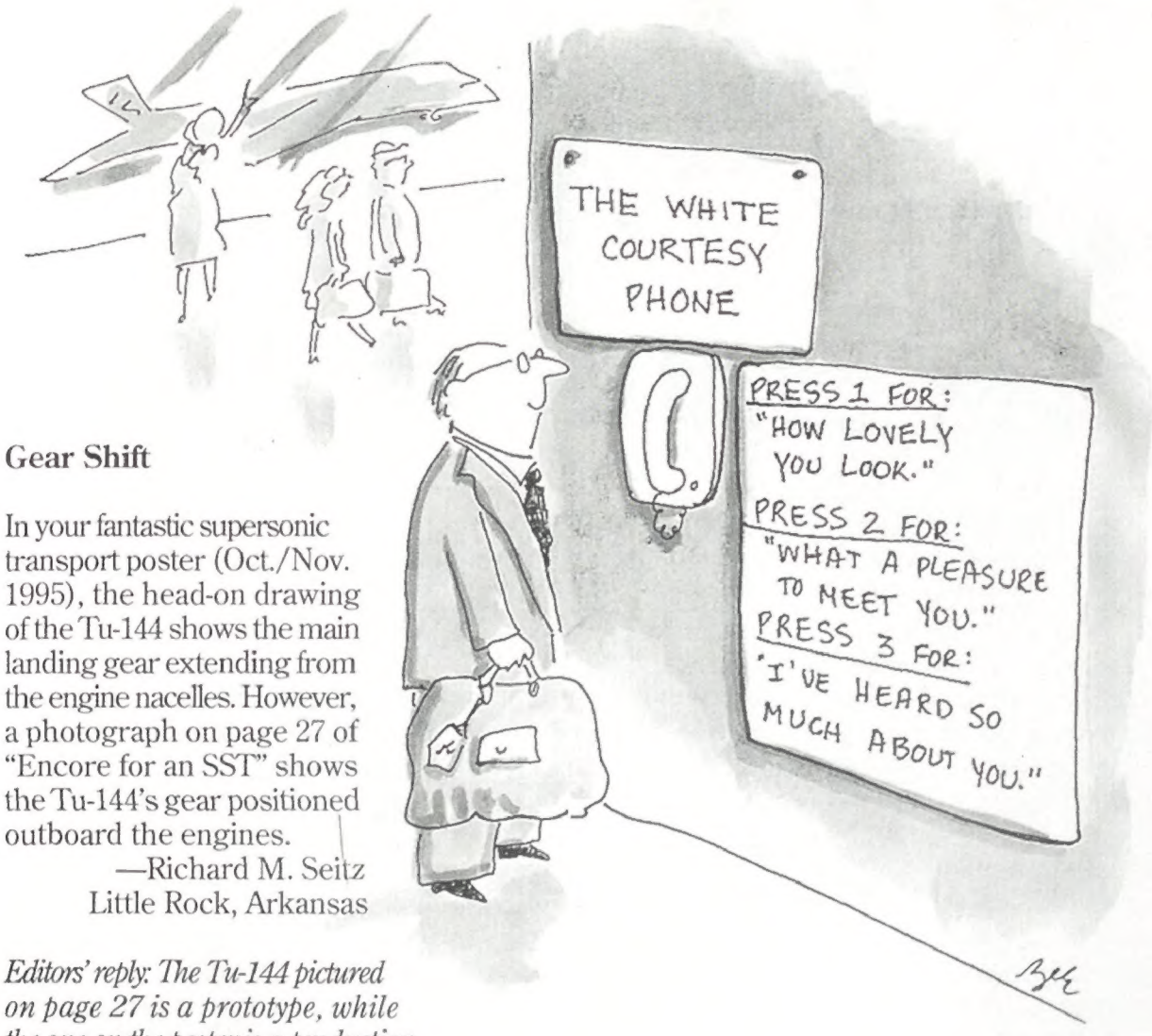
—Name withheld upon request

Editors' note: Archivist James H. Kitchens confirmed the above characterizations of the Air Force Historical Research Center's holdings, though he added: "U.S. Army Air Forces aircraft and air crew lost in combat during World War II can be identified only from engine serial numbers, weapon serial numbers, and aircraft master data plates (other circumstantial and forensic evidence aside). It is not possible to make an identification from component part numbers, for example, or the remains of a parachute."

Contest

Air & Space/Smithsonian and Sheaffer, makers of the new Legacy pen, are sponsoring a competition. The reader who sends in the best letter to the editor for the next issue will win a Legacy. Entries will be judged on quality of writing, not the opinions they express. The winner will be selected by the *Air & Space* staff.

Beth discovers that her date has a dark side.



Gear Shift

In your fantastic supersonic transport poster (Oct./Nov. 1995), the head-on drawing of the Tu-144 shows the main landing gear extending from the engine nacelles. However, a photograph on page 27 of "Encore for an SST" shows the Tu-144's gear positioned outboard the engines.

—Richard M. Seitz
Little Rock, Arkansas

Editors' reply: The Tu-144 pictured on page 27 is a prototype, while the one on the poster is a production version, the Tu-144D, which represented a drastic revision.

Been There, Done That

Only a year or so before Lindbergh died, he and I corresponded about the low-rpm technique described in "On Lindbergh's Wing" (Above & Beyond, Oct./Nov. 1995). Lindbergh said he'd used a less developed version for his transatlantic *Spirit of St. Louis* flight. In addition to pulling back the propeller revolutions, the technique involved raising manifold pressure. Lindbergh wrote that the combination could add more than 100 miles to a P-38's combat radius.

A Ford Motor Company engineer told me that the technique works for cars too, albeit in a modified form, and that Ford adapted it to engine controls long ago.

—Captain Thomas F. Norton
U.S. Naval Reserve (ret.)
Easton, Maryland

Two of your recent stories prompted me to share some reminiscences.

While I have no trouble believing Lindbergh had a hand in developing the low-rpm technique, he was not the first. In January 1944 I arrived at Landhi Field near Karachi in India; Landhi was the fighter operational training unit for Claire Chennault's 14th Air Force. There I learned a last-ditch measure pioneered by Chennault himself: You pulled the prop control all the way back, giving about 1,400 rpm, then advanced the manifold pressure to hold minimum cruising speed. Of course, you already had the mixture control as far back as possible. I'm sure the honchos of the U.S. Army Air Forces were happy to see Lindbergh come forward with his low-rpm idea. They would have hocked their swagger sticks rather than admit having learned something from Chennault.

Though I never witnessed a zero-length launch ("Runways of Fire," Oct./Nov. 1995), I saw dramatic evidence of the crucial center-line problem that could plague jet-assisted takeoff. One Air Force Day, probably in 1954, Major John Kropenick took off in a "clean" F-84G—one carrying no bombs or external fuel tanks—boosted with four JATO rockets. After breaking ground, he climbed at a suicidally steep angle, still with gear and

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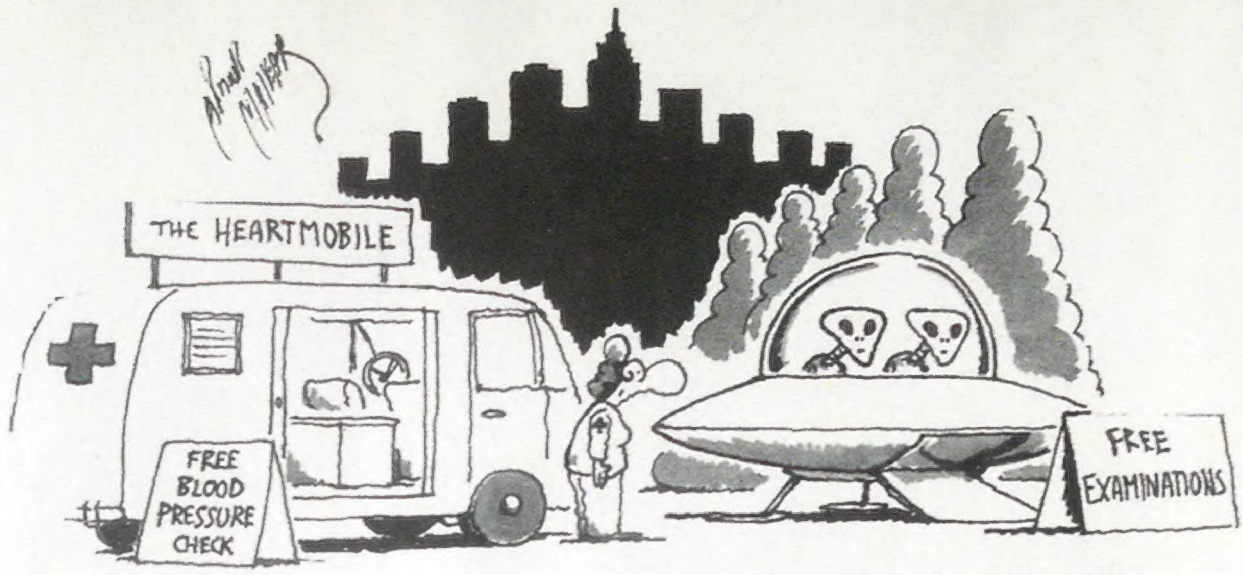


flaps down, until the rockets burned out. We thought he was showboating, but when he got down he confided that it had taken both hands on the stick to keep from stalling. It turned out that the JATO installation center line had been calculated for an aircraft with a full external load.

A couple of minor corrections: The F-100 was nowhere near twice as heavy as the F-84, unless you are comparing the former's maximum gross with the latter's internal-fuel-only weight. And the T-63 was not a nuclear warhead. It was an inert ballistic shape representing the Mark VII A-bomb.

—Major David H. Rust
U.S. Air Force (ret.)
Woodville, Texas

Look on the Bright Side

The otherwise excellent article "Astronomy's Hot Spot" (Oct./Nov. 1995) omitted mentioning the longest running, most productive astronomy research under way at the South Pole—the study of the sun. Since 1979-1980, when Martin Pomerantz of the University of Delaware initiated solar observations there, four National Science Foundation-supported groups have spent a total of nine summers at the pole studying the sun.

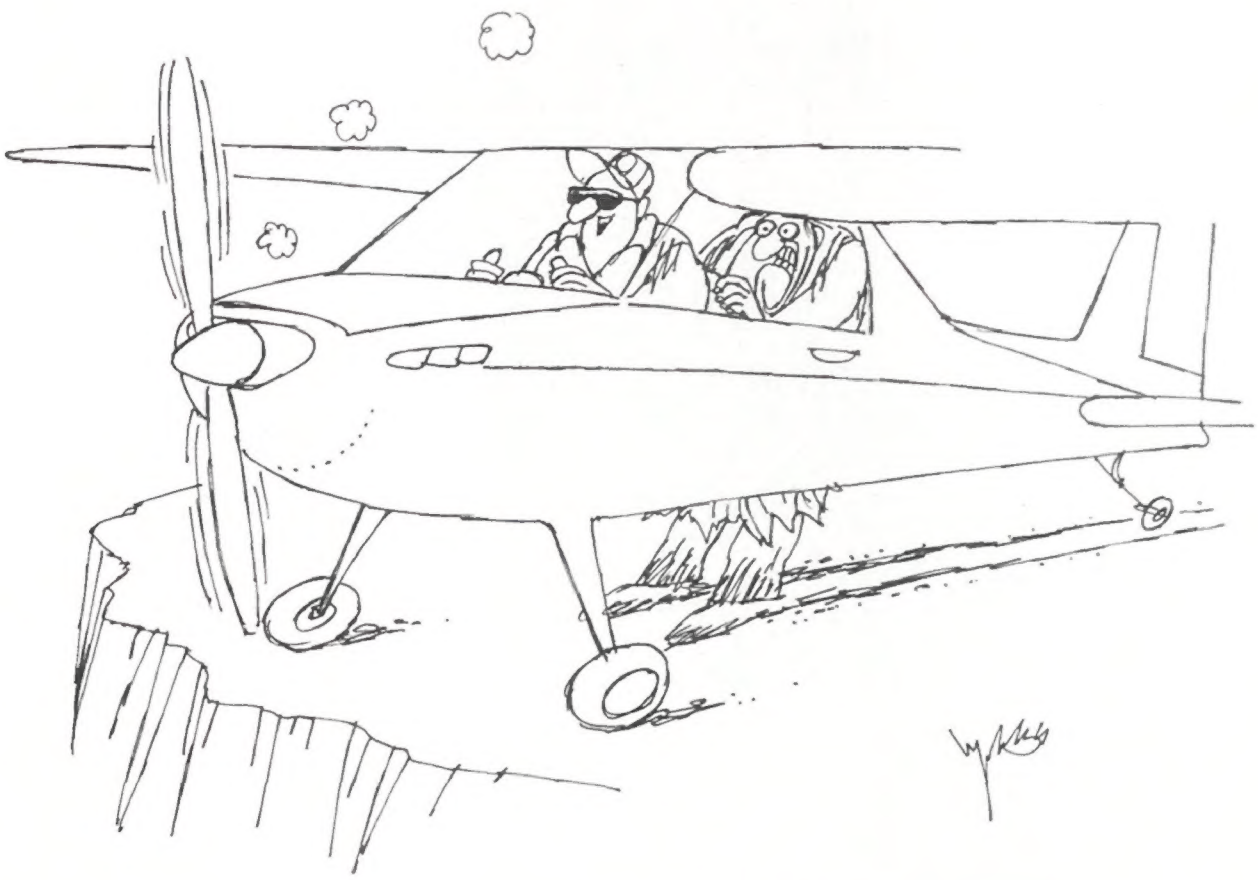
Like non-solar astronomy, solar research benefits from the South Pole's clean sky and long periods of uninterrupted viewing. Scientists stationed there can study how solar activity changes over time scales that cannot be observed elsewhere, and they can investigate the inside of the sun by seismology. A lot of what we know about the solar interior came from observations made at the South Pole.

Ground observations of the sun's surface have never been surpassed in resolution by observations made in space. Until the advantages of space observing become available, ground-based observations, such as those at the South Pole, will remain our main way of studying the sun.

—John Harvey
Tucson, Arizona

Bombing Basics

In "The Secret Weapon" (Feb./Mar. 1995), Don Sherman writes that the precision strategic bombing doctrine was flawed and that under the harsh realities of war, precision bombing gradually evolved into the shotgun approach.



"Well, the old girl still has brakes!"

General Hap Arnold promoted the doctrine knowing full well that he did not have the accuracy and that large bomber formations were required, not only to increase target hits but to deliver the tonnage required to take out the target.

The doctrine that a bomb group could defend itself was not completely flawed. At least two groups in the 15th Air Force believed and practiced FFTF—"Fighters Fear Tight Formation."

Regarding the technique of turning while on the bomb run, once you are within 15 seconds of the target, no further correction should be made. The formation is committed to the track they are making. When the bombs are released, they are traveling at the speed of the airplane and on the same heading. As the bombs fall, the only force acting on them is gravity. Any movement caused by the wind is infinitesimal.

—Richard W. Phelps
Fulton, New York

Corrections

Oct./Nov. 1995 SST Poster: In addition to the 18 Concordes referred to under "Number produced," there were two earlier prototypes.

Aug./Sept. 1995 "The Last Raid": Tallboy bombs weighed 12,000 pounds, not 22,000.

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AERODYNAMIC ORIGAMI

CHAD SLATTERY (2)

Last spring, Bo Rutherford, then a fourth grader in Thousand Oaks, California, was flying paper airplanes in science class when he thought, *Wouldn't people who make real airplanes make really good paper ones?* Rutherford pitched his idea to Malibu-based entertainment entrepreneur Cary O'Neal, who in turn asked aerospace firm officials to participate in what he dubbed the World's Greatest Paper Airplane Contest—"and got shot down several times," he says.

Undaunted, O'Neal went straight to the engineers, and he found a cadre of McDonnell Douglas employees who had been holding an annual in-house competition for nearly 20 years. With their support, he announced in *Aviation Week & Space Technology* that the contest would be held at McDonnell Douglas' Long Beach plant—much to the surprise of the firm's public relations department, which knew nothing of its role as host.

When communications got straightened out and feathers were smoothed, the World's Greatest Paper Airplane Contest got under way on September 9 with some three dozen participants from Rockwell, Boeing, Northrop Grumman, Lockheed Martin, McDonnell Douglas, and Cessna. Bo Rutherford was spruced up in a suit to play on-air host for the video O'Neal hopes to sell to a cable channel.

Competition was divided into three classes, each requiring construction from a single 8.5- by 11-inch sheet of paper: Class A, for long-winged aircraft built to achieve maximum flight duration; Class B, for scale models of operational aircraft; and Class C, "Fold and Fly," in which participants created their aircraft on the spot. Each entry got a maximum of eight flights, from which the two longest times were added to yield a score.

Some engineers had come on a lark, like Northrop Grumman aerodynamics and integration designer Barnaby Wainfan, whose Class B entries included a B-2 bomber, a space shuttle, and a Lippisch DM-1, which the professorial Wainfan described as "an exceedingly obscure World War II German glider built to test the configuration for what they hoped would be the world's first supersonic fighter airplane."

That unlikely squadron was beaten by McDonnell Douglas engineer Brian Lindley's RB-57, a reconnaissance version of the 1950s-era twin-engine B-57 bomber, which scored a winning total of 39.7 seconds. The Class A plaque went to McDonnell Douglas engineer David Peterson, who spends his weekdays "working on trying to replace existing aluminum wings on commercial aircraft with carbon composites." His big glider racked up a total of 61.1 seconds.

At the other end of the time-and-effort spectrum was the delicate little glider made on the spot by James Zongker, a Cessna engineer in Wichita. Lanky, nervous, and twitchy as a greyhound, Zongker climbed the launch tower and cupped the airplane in his outstretched hands, easing it into the air like a baby bird. "It's supercritical, structurally," he explained. "If you get the slightest bad launch, just forget it, it's all over. The wings just roll up and it pitches down." More often, though, he achieved flight, clinching the Class C prize with a total time of 34.8 seconds.

At the end of the competition, Bo Rutherford stood on a milk crate, and, surrounded by participants, faced the camera and repeated a question fed to him by O'Neal. "Do you guys have day jobs?" "This is our day job!" the entrants shouted in coached unison, grinning and holding up their paper airplanes.

—Norman Kolpas

UPDATE

Astronomers Hit Pay Dirt

Swiss astronomers announced last October that they have discovered a planet orbiting a fifth-magnitude star in the constellation Pegasus ("The Planet Hunters," Oct./Nov. 1992). The planet, which completes one orbit every four days, grazes star 51 Pegasi's corona, where the temperature is 1,800 degrees Fahrenheit. Stephen Maran of the American Astronomical Society calls the discovery of what is probably another solar system "one of [astronomy's] so-called holy grails."

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UPDATE

Bennett Balloon Racers Killed

During the 1995 Gordon Bennett balloon race ("Fierce to Win," Feb./Mar. 1994), U.S. competitors Alan Fraenckel and John Stuart-Jarvis were killed when their balloon was shot down by a Belarussian helicopter gunship last September. Three balloons competing in the race had crossed the border between Poland and Belarus and were confronted by military helicopters, despite having received government approval to enter Belarus airspace before the race began. The crews of two balloons signalled with flags and were permitted to land, but "D-Caribbean" gave no acknowledgment. After firing warning shots, the helicopter pilot became convinced that the balloon was unmanned and shot it down with 20 rounds.

NASA's Wide Open Spaces

Henk Brink of the Netherlands needed help ensuring that the envelope of his helium balloon—the world's largest—was airworthy prior to his round-the-world nonstop flight. He ended up in the cavernous Vehicle Assembly Building at NASA's Kennedy Space Center in Florida.

Brink rented the VAB for a weekend last September to conduct a leak check of the 200-foot-tall balloon. Brink and his crew, copilot Willen Hageman and flight engineer Wout Bakker, plan to launch sometime before next February and complete the circumnavigation in about 12 days. The high-altitude cruise would break the current endurance record of six days aloft in a balloon.

"We looked all over Europe and Russia," Brink says, "but there was no place where we could safely inflate this balloon." It couldn't be done outdoors, because with 12,000 square feet of surface area, the envelope is also the world's biggest spinnaker. Then Brink called NASA. "It was a present from heaven" when the space agency said yes, Brink says. He gave NASA a $25,000 deposit for the use of the VAB on a cost-reimbursable basis, saying money was no object.

The balloon crew, aided by NASA engineers, partially filled the 700,000-cubic-foot envelope with helium, taking care not to let the delicate cloth scrape the steel skeleton of the VAB. The balloon didn't begin to fill a fraction of the huge structure, which first sheltered the Saturn Vs of the Apollo era. "Last night, when we left the building, we measured the lifting force," Brink says, "and when we came back this morning the lifting force was still the same as when we left. That means the leakage is zero."

With a pressurized gondola, the craft's takeoff weight is about 21,000 pounds. It's designed to ride the jet stream, 36,000 to 40,000 feet up, and will carry a variety of ozone sensors and science instruments from Russia and Europe.

—Beth Dickey

SCOTT ANDREWS

UPDATE

By Thrust Alone

Bill Burcham's Propulsion-Controlled Aircraft system scored high marks last August when former astronaut and NASA-Dryden pilot Gordon Fullerton brought a McDonnell Douglas MD-11 to a safe landing at Edwards Air Force Base in California solely by varying engine thrust (From the Field, Apr./May 1995). The system uses the MD-11 autopilot pitch thumbwheel and heading knob and PCA programming in the flight control computers to implement varying thrust commands to the wing-mounted engines, increasing and decreasing thrust to climb and descend and increasing left engine thrust while decreasing right thrust to turn right. Future tests will investigate controlling speed by adjusting the thrust of the tail-mounted engine.

CLIFF BARBOUR

Up on the Roof

During the 1912 Portland, Oregon Rose Festival, Silas Christofferson, a 23-year-old aviator and auto racer, thrilled a crowd of 50,000 by flying his Curtiss Pusher off the roof of Portland's Multnomah Hotel. In 1937, on the 25th anniversary of the flight, an *Oregonian* newspaper writer commented, "The flight of Christofferson from the Multnomah Hotel will be long remembered by Portlanders, as it has never been done again, and probably never will."

He was wrong. On a Saturday afternoon last September, Tom Murphy gripped the oak control wheel of his Curtiss Pusher replica. The aircraft was perched at the end of a 200-foot plywood ramp mounted on scaffolding five feet above the roof of the Multnomah Hotel. Reg Tufts, Murphy's assistant, spun the wooden propeller, the 85-horsepower engine started, and the Curtiss accelerated down the ramp. Judging the wind by a line of purple balloons on the scaffolding, Murphy lifted the airplane's nosewheel off just four feet from the ramp's end. Jerry Baas, a Federal Aviation Administration official, later said, "You should have seen the look on his face. It wasn't fear but sheer determination. He was going to make it fly."

The Curtiss dipped a bit as it cleared the hotel, then headed down Third Avenue toward the Willamette River, where Murphy picked up his escort, a trio of helicopters. A half-hour after leaving downtown Portland, the Curtiss touched down at Pearson Field and taxied to the airfield's museum hangar, where a balloon arch, an accordion-and-spoon band, and about a thousand people received him as an heroic aviator. "This is the best thing that's ever happened to me," Murphy said.

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powerplant mechanic, Murphy is a wiry, soft-spoken man of 49. He has about 25 hours of flight time in the Curtiss, which he bought from its Michigan builder in 1991. Back in 1912, Silas Christofferson had disassembled his aircraft, taken it to the roof in the hotel elevators, and reassembled it. Murphy's aircraft was flown from Pearson to a vacant lot near Portland's train station, then wheeled by hand to the street outside the hotel. Just after rush hour one evening, the Curtiss was lifted to the roof by helicopter.

Organizers of the event had to secure permits and paperwork from some 20 agencies and government departments, ranging from the FAA to the Portland police. Bob Braze, an FAA aviation safety inspector, praised the organizers' approach, noting that Murphy had demonstrated he could get the airplane airborne with a 200-foot takeoff run during a test flight at Pearson on a hot day. A fellow FAA inspector confided, "When they first came to us we said, at least to each other and ourselves, 'Are you nuts?' We had a thousand questions, a thousand what-ifs, but they had a thousand good answers. We made some minimal suggestions."

Murphy's publicity stunt kicked off a fundraising campaign to complete the Pearson museum and preserve the historic airfield (see Collections, Aug./Sept. 1994). No one seems to know exactly how much the event cost, but, as John Wulle, Pearson Field Historical Society chairman, notes, "Harebrained stunts are expensive."

—Thomas Wm. McGarry

Crash Test

The 10-second countdown begins at NASA's Plum Brook Station outside Sandusky, Ohio. Jet Propulsion Laboratory engineer Tom Rivellini crouches in front of a bank of video monitors that show simulated Martian landscapes. At "three, two, one, *release*," a 17-foot-wide cluster of airbags drops 70 feet in the world's largest vacuum chamber. Accelerating to 62 mph, the

JPL

bags slam onto the faux Martian hill, a platform covered with jagged rocks.

The bags bounce into a restraining net and slowly deflate. This test was the most extreme to date, but there is just one tear, in an area that engineers had already decided to reinforce on future bags. Rivellini turns from the monitors and gives a thumbs-up to his colleagues. "We did pretty good," he says.

The airbags are one drop closer to Mars. They will be carried to the Red Planet aboard Pathfinder, an unmanned craft with a lander and rover that will touch down on Mars on July 4, 1997. As Pathfinder enters the Martian atmosphere, it will be slowed, in succession, by the craft's heat shield, a parachute, and retro-rockets.

A rocket-assisted touchdown would contaminate the soil the lander will analyze, and a parachute alone wouldn't slow it sufficiently in Mars' thin atmosphere. Instead, the rockets and parachute will brake the craft to a halt before it touches down, with the lander dangling from a tether 40 feet above the surface. When the tether is cut, the 640-pound lander will fall. The package is expected to bounce and roll on the surface before coming to a stop, but it will be cushioned by the cocoon of airbags, which will inflate seconds before impact. Their job done, the bags will deflate and the lander will open like a three-petal flower. On the portion still hovering, the rockets will then fire and drop the parachute assembly a safe distance from the lander.

Development of the bags is being rushed so they will be ready for Pathfinder's December 1996 launch. The tests at Plum Brook, a field station for NASA's Lewis Research Center, are studying the integrity of the bags' polymer fiber, Vectran, which is used in high-performance yacht sails. One finding is that multiple layers of lighter fabric hold up better than a single layer of heavier material. "The outer layer was tearing, absorbing energy, but more importantly creating a buffer, like a soft blanket over the rock," Rivellini says, "and therefore the second layer didn't get all these sharp little edges and corners digging into it."

—Ted Scala

UPDATE

Honors and Awards

Sherwood Rowland and Mario Molina, who reported in 1974 that chlorofluorocarbons in propellants and refrigerants were destroying the ozone layer ("Ozone Forecast: Partly Cloudy," Oct./Nov. 1994), won two of the three 1995 Nobel Prizes for chemistry.

Neal V. Loving, a pioneering black airman and autobiographer (In the Museum, Oct./Nov. 1994), was named an Honorary Fellow in the Society of Experimental Test Pilots last September.

The 12 crewmen of an RB-29 reconnaissance bomber that was shot down off Vladivostok by two MiG-15 fighters on June 13, 1952 ("Beyond the Iron Curtain," Aug./Sept. 1994), were posthumously honored with Distinguished Flying Crosses and Purple Hearts at a ceremony at Maryland's Fort Meade last October. The loss of the cold war spyplane and its crew is one of 10 incidents currently under investigation by a joint U.S.-Russian board. Previously, the families of ferret-flight crewmen who were shot down by the Soviets were told that the servicemen had vanished during a noncombat flight.

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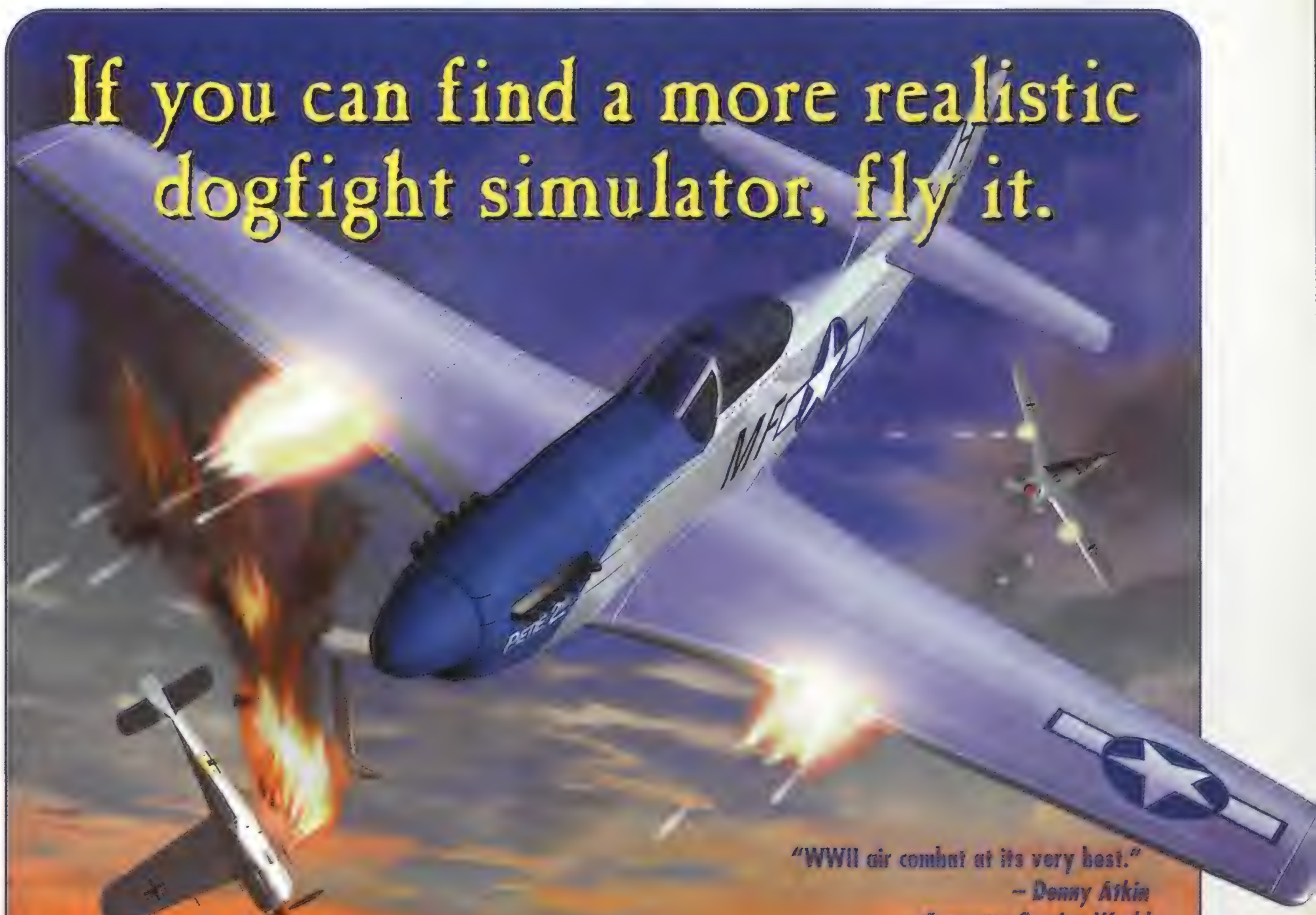

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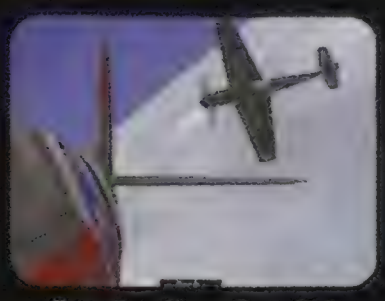

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The Dynamic Duo

They were a disheveled pair—grimy, unshaven, cigarettes perpetually dangling from their lips. But their sassy and insightful commentary on the frustrations of Army life endeared them to thousands of American soldiers during World War II. They were Willie and Joe, the wise-cracking GI duo created by political cartoonist Bill Mauldin.

From 1940 to 1945, first as a cartoonist for the *45th Division News* and later for the overseas Army daily *Stars and Stripes*, Mauldin captured the soul of the U.S. infantry in his drawings. During the war, he prowled foxholes with pencil in hand, creating nearly 500 cartoons and unforgettable images: Willie and Joe, dirty and rumpled as ever, taking a rest in a doorway under the disapproving eye of a corporal. "He's right, Joe," says the battle-weary Willie. "When we ain't fightin' we should act like sojers." Or the two officers enjoying a sunrise from high atop a mountain. "Beautiful view," says one. "Is there one for the enlisted men?"

"Willie and Joe were inspired by the guys in K Company," recalled the 74-year-old Mauldin at a World War II symposium at the Museum of Flight in Seattle last August. "The company was about one-third Choctaw Indian and the rest were Oklahoma farm hands. They were great guys, though most died early on. In fact, that's what I hated about the infantry: The only way out was feet first."

Despite his years in the infantry, the New Mexico native said his first love is aviation. "I built airplane models as a kid. During high school I washed down planes for free flying lessons. When I joined the Army I wanted to go into aviation, but I flunked out my last year of high school and couldn't qualify."

After a year at the Chicago Academy of Fine Arts, Mauldin joined a National Guard unit in Oklahoma, which was part of the 45th Infantry Division. "It was in the 45th that I met Walter Harrison, who had been the editor of the *Daily Oklahoman* and the *Oklahoma City Times*," Mauldin recalled. "Harrison had started a four-page weekly called the *45th Division News*. Some of my cartoons accidentally fell into his hands and he liked them. I began turning in one a week."

Mauldin's cartooning reputation grew. Shipped overseas with the 45th in 1943, he was eventually assigned to the big Army daily. "They were afraid of me at *Stars and Stripes*, because I was pretty disrespectful of the officers corps," he said. "They didn't want my cheeky cartoons to jeopardize the good life they were leading. I liked the assignment because I was finally safe from the infantry."

His irreverent commentary continued to irk the brass, notably General George Patton, who threatened to court-martial him. In an effort to smooth things over, Mauldin visited the general at his Luxembourg headquarters. "Patton gave me the history of the Army—of *all* the Army," he recalled, "and then chewed me out for 45 minutes. It was quite an experience."

In 1945 Mauldin won a Pulitzer Prize; at 23, he was the youngest person ever to receive the award. He won a second Pulitzer in 1959. A few years ago he was forced to give up his job as a political cartoonist for the *Chicago Sun-Times*, where he had worked for 30 years. He had lost the use of his drawing hand in an accident that was a fitting end for Willie and Joe: A hoist dropped an old Army-issue Jeep on his hand while he was hooking up a snow plow.

Mauldin still keeps tabs on his scraggly duo. What would Willie and Joe be doing today? "They'd be struggling to survive," Mauldin said, "same as always."

—Rita Cipalla

NASA LANGLEY

Citing a need to consolidate facilities in "a time of shrinking federal budgets," NASA's Langley Research Center in Virginia closed its 30- by -60-foot subsonic wind tunnel last September and is considering "adaptive uses" for the facility, which began operations in 1931. Because it was designated a national historic landmark in 1985, the Full-Scale Wind Tunnel, which is 434 feet long, 222 feet wide, and 97 feet high, cannot be substantially altered. Got any imaginative uses for the facility? Send them to Wind Tunnel, Air & Space/Smithsonian, *901 D St., SW, Washington, DC 20024. E-mail to airspacedt@aol.com, subject: alt.windtunnel.*

UPDATE

Celestis, Resurrected

Orbital Sciences has contracted with Celestis, Inc. to provide secondary-payload launch services for cremated human remains. Celestis, which in the mid-1980s attempted to provide a similar service in Florida with a dedicated satellite ("Dollars from Heaven," June/July 1986), has reopened for business in Houston. The price to send a lipstick-size container of ashes on the third stage of a Pegasus or Taurus booster, which will eventually reenter the atmosphere and burn up, is $4,800. Celestis, which plans to make its first launch in 1996, figures 1,000 capsules could be accommodated per launch. The company hopes to capture one percent of the cremation market.

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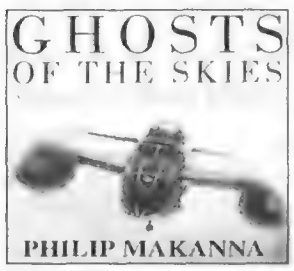

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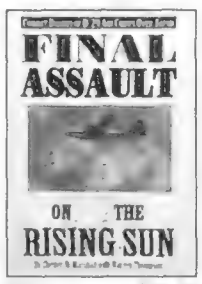

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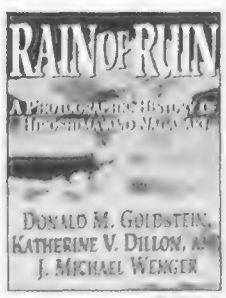

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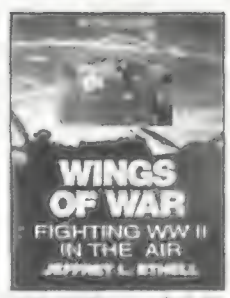

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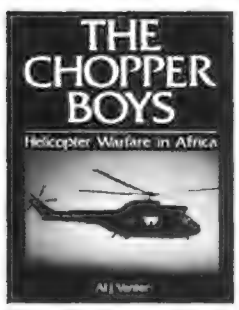

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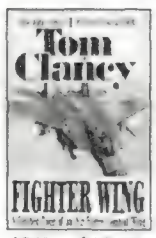

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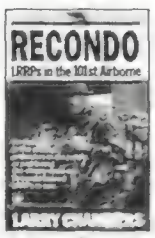

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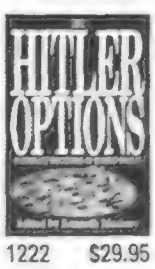

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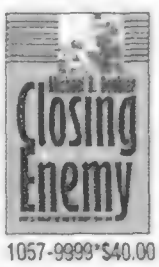

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Funny You Should Ask

"How high is the sky?" Mary Pavlovich, the circulation librarian at the National Air and Space Museum's library, recently took this question from a caller who reported that, after searching many books, he still could not find a satisfactory answer. "I referred him to the [Museum's] planetarium," says Pavlovich.

People seeking quick answers frequently telephone the library and archives reference desk. Most questions reveal a seriousness of purpose. Then there are others, which go something like this:

Caller: "Can you tell me how fast a B-17G could fly with a 20,000-pound bomb load?"

Museum staffer: "I'm sorry sir, but the B-17G could not carry such a load."

Caller (*turning away from the phone*): "I win, Fred! I told ya the airplane couldn't do it!"

Dan Hagedorn, the head of the reference desk, describes this type of question as a "bar bet" call. "We get lots of them," he says, "like 'How many golf balls are still on the moon?' [answer: two], and they're usually the result of a barroom discussion. Sometimes you can hear music and laughter in the background."

The Museum's reference desk must respond to the public's inquiries, even if it means settling drinking disputes. And even if it means listening to someone who thinks he's solved the mystery of Amelia Earhart's disappearance. "The caller had purchased a Chinese-made pocketbook at a flea market," relates Hagedorn, "and claimed that it literally held the key to the mystery." It seems that in the lining of the bag the man had found a luggage key stamped with the initials A.E. Based on his find, he had concluded that Earhart had been on a spy mission, had been shot down by the Japanese, had somehow wound up in China, was being kept captive in a Chinese handbag factory, and had slipped the keys into this particular pocketbook to let the world know she was still alive. In fact, the key came from a piece of luggage that was part of the Amelia Earhart line.

Then there was the time Amelia Earhart herself called—in the form of a woman who believed she might have been the famed aviator in a former life. Exercising great diplomacy, archive technician Tim Cronen fielded the call. Any illusions the woman might have had were quickly shattered when Cronen mentioned that the Museum owns Earhart's Lockheed Vega. "What's a Vega?" she asked. Cronen speculates that the caller may have been influenced by then-current publicity about the finding of what was alleged to be a piece of Earhart's airplane in the South Pacific.

It was not the first time that media ballyhoo had prompted queries. "In the span of a few days, we got about a dozen calls asking for the identity of the 'oldest continuously operating airport in the U.S.,' " says Hagedorn. "I asked a few questions myself and learned that a Cleveland radio station was using this question in a contest." [The answer, for a land-based airport, is the one in College Park, Maryland.] Sometimes it's the media itself that calls. The staff of the television quiz show "Jeopardy," says Hagedorn, has called several times to verify the accuracy of an answer.

The Museum staff refers to queries of this type as Ready Reference Questions—those that can be answered within five or ten minutes. "People are constantly calling to ask 'What is the speed of sound?' " says Hagedorn, "or 'How long did it take the Apollo missions to reach the moon?' " Other queries are more elaborate, and these get written replies. "It is not unusual to handle 30,000 letters, calls, and e-mail requests in a year," says chief photo archivist Melissa Keiser. How does the small staff handle such a large workload? "We write fast," says Keiser, "very fast."

In addition to responding to written and oral requests, the staff assists visitors

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doing in-person research. "Rather than be a sterile archive open only to academics," says Hagedorn, "we choose to be a museum for the world," open to anyone from the ordinary to the famous. The well-known who have done research at the Museum include *Enola Gay* pilot Brigadier General Paul W. Tibbets, Apollo 11 astronaut Buzz Aldrin, and Brigadier General Charles E. "Chuck" Yeager, who flew a Bell X-1 past Mach 1 in 1947.

Not all requests come from aviation buffs and aerospace professionals. "We get letters from prison inmates asking us to send information on how they could build themselves an ultralight," says Hagedorn. "I assume they want a VSTOL—a very-short-takeoff-and-landing type." Another inmate requested plans for building a 1:8-scale DC-3, which he wanted to power with two motorcycle engines.

Requests like these keep the hard-working staff chuckling and relieve the stress of dealing with the inevitable irritations of the job. Hagedorn says the only requests that irk him are those in which the person writes or calls to ask for "everything you have" on some wide-ranging topic. "Everything you have" is a big request for a facility that owns 29,000 books, 11,000 bound periodicals, and more than 10,000 cubic feet of archival material, including 1.7 million photographic images.

All of these holdings are, however, available to the public. You'll need an appointment, but it's easy to set one up. Just give the reference desk a call at (202) 357-3133.

—Stan Solomon

A Modeler's Tale

Dave Gianakos, 41, is a pilot for Northwest Airlines. He flies 747-400s on international routes, and between trips he has as much as two to three weeks of down time, which he spends at home in Littleton, Colorado. It's a good deal for Gianakos' wife and three daughters, and his work schedule also allows him to pursue a demanding hobby: scale modeling.

Gianakos began making models at age six, when he put together a kit for a small plastic jet fighter. Three years later he built his GI Joe doll a Mercury model from scratch. "I made a spacecraft for the GI Joe out of lampshades," says Gianakos. "I commissioned my grandmother to make the Mercury suits to my specifications." He eventually graduated to finely crafted scale modeling, building all types of airplanes, but it wasn't until 1990 that he found his favorite subject: large flying rockets.

A year later he built and flew a 1:12-scale model of the Mercury Redstone rocket flown by Alan Shepard on May 5, 1961. His next project was a 1:34 model of the Saturn I-B that launched Apollo 7. The two-stage model, complete with computer-activated controls, flew beautifully, giving Gianakos the confidence to try an even larger flying model—a 1:34 Saturn V, the enormous three-stage rocket that launched 10 Apollo missions. Gianakos began the project in March 1992 with the hope of launching it on Apollo 11's 25th anniversary—July 16, 1994. He envisioned a realistic launch with a gyroscope and servo motors for the first stage, motors with pop-out fins for the second and third stages, and all sections returned by parachute. Five months before the anniversary Gianakos had completed everything but the rocket motors, whose construction he had subcontracted. But there were too many technical problems to finish by July, and at that point the model was "just too precious to risk launching," says Gianakos.

So he decided to find a home for his work of art. He had, after all, spent some $4,000 in parts and supplies and a minimum of 2,500 hours researching and building it in his basement with a variety of hand-crafted tools. The work, often tedious, consisted of poring over NASA design drawings, as well as hours of carving, welding, gluing, and airbrushing.

Model builder Dave Gianakos built a Saturn V worthy of display at the National

TERRY McCREA

The rocket, with a diameter of 11.5 inches at its widest point and a height of nearly 11 feet, is constructed of resin-coated cardboard tubing, fiberglass, wood, and a white vinyl covering. The red launch tower, made of wood and high-impact plastic, stands 14.5 feet from base to antenna. Since the model was too tall to stack in the basement, Gianakos hauled the whole thing upstairs and into the yard when he needed to check his work. "I'd have to recruit my wife to carefully bring it up the stairs," he says.

He approached several regional museums about taking his model, but in the back of his mind he dreamed of only one place for it: the National Air and Space Museum. "Almost as a lark, I called [the Museum], not really expecting that they'd have any interest in this," says Gianakos. But someone in the Museum's department of space history told him to send in some photos. "I was struck by its obvious high quality—superb," says Frank Winter, the curator of rocketry. He took the model under his wing, and 18 months later it was unveiled, appropriately, in gallery 210, "Apollo to the Moon."

Before the model could go on display at the Museum, however, Gianakos had to get it there. Fortunately, both the tower and the rocket disassemble into a total of nine sections, which were packed in wooden crates made by Gianakos' brother-in-law. The contents, which have been appraised at $50,000, were shipped by a commercial air service to the Museum's Garber storage facility in Suitland, Maryland. There the crates sat unopened for 13 months while final preparations for exhibition were made. "I had a lot of trepidation about what to expect," says Gianakos, "but as soon as we started opening the crates, we saw that there was not anything broken." Last September, Gianakos, aided by his brother-in-law and father-in-law, assembled the model inside the gallery as visitors stopped to look and take photographs. Seeing his work exhibited in a national museum is "just an extreme thrill for me," says Gianakos. "I couldn't be happier."

Gianakos' family is supportive of his hobby, though, he says, "I probably wouldn't do another project this big again." But when the Museum needed someone to build a model of the Soviet's failed moon rocket, the N-1, for an exhibit opening next year, the staff couldn't think of anyone better suited than Gianakos. He accepted the assignment, ensuring that his craftsman's hands won't be idle for the next few months.

—Diane Tedeschi

Museum Calendar

Except where noted, no tickets or reservations are required. To find out more, call Smithsonian Information at (202) 357-2700, Mon.–Sat., 9 a.m.–4 p.m.; TTY: (202) 357-1729.

December 2 "100 Years of X-Rays." Ed Frederick, curator of astronomy at the New England Science Center, discusses the history of the X-ray. Einstein Planetarium, 9:30 a.m.

December 14 "Building a 1911 Wright Model B." Airline pilot Ken Hyde details his experiences building a Wright Model B for the U.S. Army Aviation Museum. Langley Theater, 7:30 p.m.

December 16 "Holiday Stars: The Winter Sky." Join Cheryl Bauer of the Einstein Planetarium in exploring winter's sky. Einstein Planetarium, 10:00 a.m.

Holiday Family Video Festival. Dec. 2, *Firebirds*, PG-13; Dec. 9, *The Last Starfighter*, PG; Dec. 16, *Flight of the Navigator*, PG. Briefing room, lower level, 10:30 a.m.

Free Classes for Children and Adults

Classes run twice daily at 11:00 a.m. and 3:00 p.m. To register, call (202) 786-2106 or TTY: (202) 357-1505.

December 1 Origami Workshop. Create a holiday menagerie of birds, cranes, and other flying objects. Milestones of Flight Gallery.

December 5 "Garbage in Space." A discussion comparing waste disposal on Earth and in spaceflight. Gallery 210.

December 13 "Could You Be an Astronaut?" Find out if you have the right stuff. Space Hall.

National Air and Space Society

The National Air and Space Museum invites you to become a founding member of the National Air and Space Society. Your support will help the Museum's efforts to build an extension at Dulles International Airport, which will display such artifacts as an SR-71 Blackbird, the space shuttle *Enterprise*, and the B-29 *Enola Gay*. To receive your membership packet, write to: National Air and Space Museum, Room 3733, MRC 321, Washington, DC 20560.

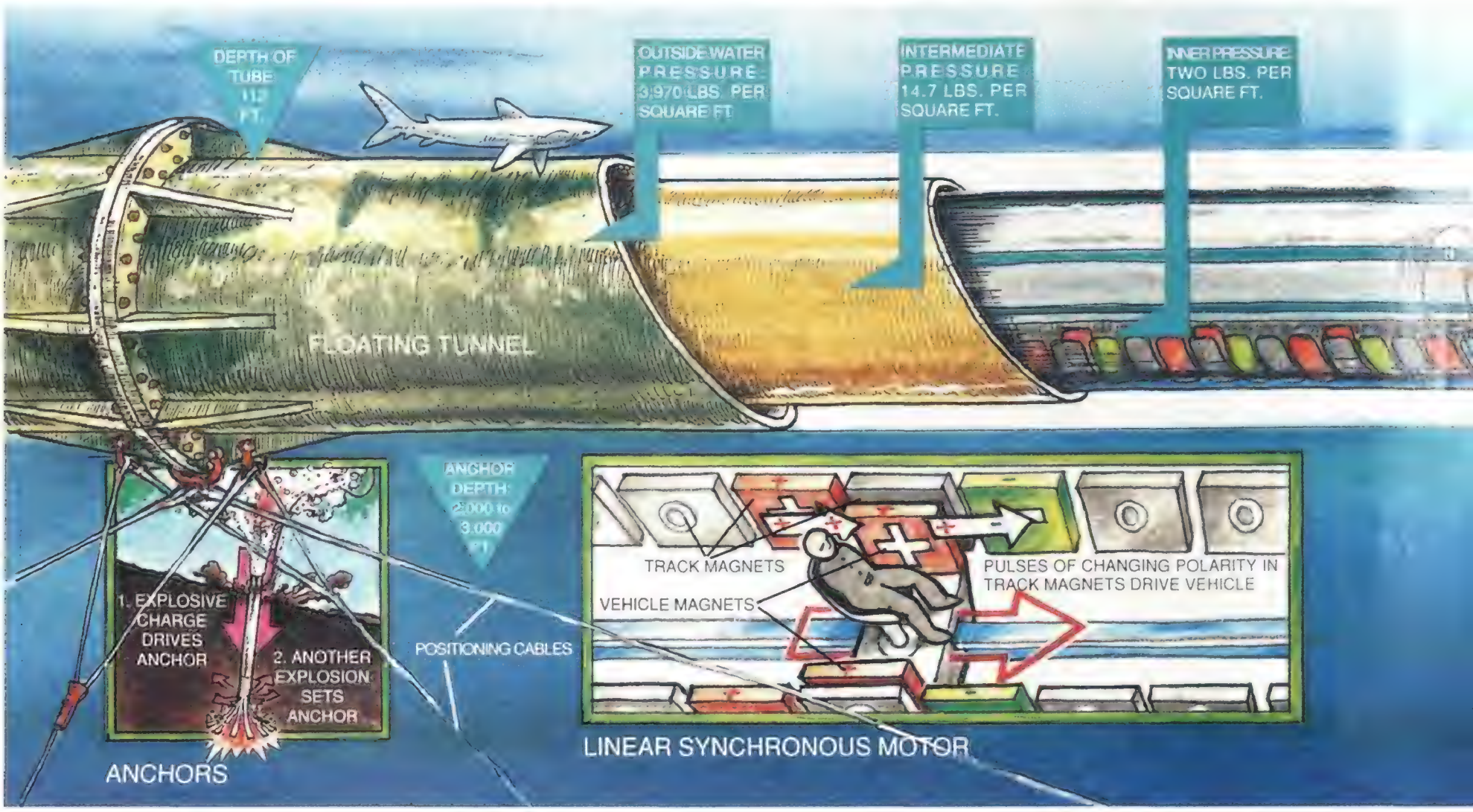
An Express of the (Near) Future

One hundred years ago, Jules Verne, in his short story "An Express of the Future," described an imaginary subway ride from Liverpool, England, to Boston, Massachusetts, that took a little over two and a half hours. "And what extraordinary consequences arise from such a rate of speed!" the protagonist's guide says: "Quitting Liverpool at noon, for example, the traveller will reach the station where we now are at thirty-four minutes past nine in the morning—this is to say, earlier than he started!... I don't think one can travel quicker than *that*!"

Certainly in Verne's day this was a case of pure science fiction. Yet a recent 15-year series of inquiries carried out by the Massachusetts Institute of Technology's Macro-Engineering Research Group shows us not only that such a rapid train journey is possible, but that electro-magnetically levitated and powered trains flying through virtually airless tubes could easily complete the trip in less than an hour. What's more, the technology to do so is nearly within our grasp.

For the past 11 years, an electromagnetically levitated train, or MAGLEV, has been in continuous commercial operation, shuttling passengers between England's Birmingham International Airport and the railway station at the National Exhibition Centre at a top speed of 25 mph. The MAGLEV was designed with the advice of one of the engineers behind the first British train to lack a traditional undercarriage, the experimental "Hovertrain," and powered by a linear electric motor—an electric motor laid out flat instead of round. Its forerunner, built by two engineers at MIT in the mid-1970s, was a splendid miniature MAGLEV that ran with astounding reliability on a 400-foot-long guideway.

Nonetheless, for years the idea of trains flying through tunnels at supersonic speed had been only a topic for semi-humorous speculation. Then, at 1978 meeting of the American Association for the Advancement of Science, Robert Salter of the RAND Corporation reported on his studies and designs of high-velocity tube flight. As a senior research associate with MIT's Macro-Engineering Research Group who has long been interested in the use of tunnels for transportation, I had been invited by the AAAS to organize this session. We were fortunate that the event coincided with Salter's readiness to publish his findings: the physicist was at the zenith of a career as designer and manager of major missile systems for



the U.S. Air Force.

Salter explained that electromagnetically levitated trains flying through a tube evacuated of air could reach velocities of greater than 16,000 mph. With air resistance virtually eliminated by vacuum pumps and without the friction of steel wheels on steel rails, a train propelled by a linear electric motor would have the advantages of stratospheric flight without the drawback of having to fight its way through resisting air to the thinner stratosphere.

Shortly afterwards, at an interdisciplinary lunch at the MIT faculty club, Salter agreed that for reasons of passenger comfort, a cruising speed of 5,000 mph would be preferable: With gimballed seats that could be rotated to lessen the impact of G forces on the passengers and with acceleration and deceleration carefully controlled by a computer, passengers traveling at 5,000 mph would feel only about five percent heavier throughout the trip—similar to the barely noticeable forces one would experience while flying on the Concorde.

My own reaction to Salter's speech was akin to an experience of time warp. As he revealed, step by step, the logic of his proposals, I felt a veil of unreality was being lifted: After all, the Duke of Wellington was said to have opposed the construction of railways on the basis that human beings could not survive sustained travel at 35 mph or more. Would not a reluctance on our generation's part to promote supersonic ground flight while accepting supersonic air transport be just as illogical and counterproductive?

In 1985 Salter agreed to update his summation for a conference I was co-chairing at MIT on tunneling and underground transport. He also told us that he had recently discovered that he was not the first to envision this scheme. "Planetran," as Salter called it, and for which he had provided such comprehensive systems engineering, had been originally conceived by none other than Robert H. Goddard, the father of rocketry. Goddard, he told us, had postulated going from New York to Boston by tube flight in 12 minutes.

Our group quickly ascertained that Goddard's essential studies were embodied in two patents (numbers 2,488,287 and 2,511,979, U.S. Patent Office) issued to him posthumously on November 15, 1949, and June 20, 1950. Before the first world war, Goddard had written of his idea, "A little consideration will make evident to anyone that three conditions must be fulfilled: first, friction against the rails must be eliminated by raising the cars off the rails by electromagnetic repulsion; second, friction against the air must be eliminated by propelling the cars through at least a partial vacuum; and third, the time of transit must be reduced to a minimum by speeding the cars faster and faster up to the middle of the journey, and then reversing the power and slowing down until the destination has been reached."

Anticipating the arrival of many distinguished participants at the tunneling conference, I wanted to highlight Salter's remarks with a demonstration—to my knowledge the world's first—of supersonic tube flight. However, the famous individuals and institutions I approached either had no luck building a model or declined to try at all. Late one evening I received a telephone call, on quite another subject, from my friend and Concord, Massachusetts neighbor, Ted Johnson. Ted, one of the original employees of Digital Equipment Corporation, had become famous for the success with which he led DEC's international marketing program. When I mentioned my inability to find a competent and willing model builder for the upcoming meeting, Ted told me, "Don't go to sleep quite yet. The man you need will telephone in ten minutes."

In less time than that, the telephone rang and Tom Stockebrand's voice boomed out: "I've always wondered why nobody ever built a working model of supersonic tube flight. I'll be happy to build it in my backyard on weekends." True to his word, Tom—who then headed DEC's Advanced Engineering Laboratory in Albuquerque, New Mexico—completed and tested a model within a few weeks. Our group contributed $800 for the materials and $400 for trucking the model to Massachusetts. The vacuum pump was borrowed.

In essence, the model was a light-gas gun that projected into two-inch-diameter plastic tubing and used helium to create a shock wave. The idea was not so much to accelerate something to supersonic speed, which had already been done with other such guns, but to show how something lightweight and obviously very easy to slow down in air—in this case, a Ping-Pong ball—could be coaxed to travel very fast with the assistance of a vacuum.

Alas, when the almost-900-foot length of plastic tube was assembled on the MIT athletic field, the ground turned out to be much less level than it had appeared. The Ping-Pong balls could not reach the end of the trajectory. But we were again rescued by friends from Concord: Before dawn on April 25, 1985, a retired contractor and his son loaded their truck with sandy soil, drove it to the sports ground, and

JAN ADKINS

deftly leveled the offending undulations just in time for the demonstration.

A full busload arrived at the field shortly before sunset. Tom Stockebrand, clad in rough coveralls, carried out last-minute checks on the transformer, the tubes, the pump, and the photoelectric-cell device used to record velocities. I remember the excitement growing as the members of the conference positioned themselves for a clear view of the trajectory. At one end of the field was Sir Alan Muir-Wood, senior consulting engineer for the English Channel Tunnel, the construction of which was soon to be resumed after an interval of 11 years. Nearby stood the chief geologist of the Seikan Tunnel, then under construction between the two main islands of Japan. Peter E. Glaser, inventor of the solar power satellite, had a noticeable glint in his eye.

When the instruments signalled that the ball had attained supersonic velocity, I glanced around me. On every face I saw an expression of satisfaction, one might almost say rapture, as if the audience had been present at the announcement of a new era in the nurturing of a global neighborhood.

What are the major obstacles in reaching that era? First of all, there has not thus far been a commercial high-speed subsonic MAGLEV service—a necessary preliminary, perhaps, to placing MAGLEV trains in an evacuated tube. This matter, however, is now being resolved: Germany has announced a timetable for the construction of a MAGLEV passenger service between Berlin and Hamburg. Powered by a linear synchronous motor—an electrically operated system of magnets in the track and the vehicle—it is expected to be up and running in about 10 years.

A second question has been the problem of evacuating air from a long-distance tunnel. Fortunately, the SWISSMETRO group has received seven million Swiss francs (a little under $6 million) to complete the design of an evacuated tunnel that would link the major cities of Switzerland by a MAGLEV service. (Because of the relatively short distances involved, the system will be subsonic.)

Third, although transatlantic tube flight service would be desirable, tunneling below the Atlantic could prove prohibitively expensive. Here, the most appealing alternative has been advanced by Norwegian contractors, who have proposed a "floating tunnel" across the Høgsfjord Strait—anchored just beneath the keels of ships—to carry automobile traffic. A contractors' association based on the Japanese island of Hokkaido has now endorsed the suggestion, which would obviate the need for thick (and expensive) tube walls to resist the considerable water pressure at the ocean floor.

Although these are not trivial engineering challenges, they are minimal in comparison with the daunting problems that confronted the scientists of the Apollo program. Indeed, if leaders of U.S. industry and government were to decide that supersonic tube flight was a desirable goal for the first decade of the next millennium, the means are already at hand to build a workable system.

Curiously, the biggest barrier is not necessarily a financial one. It is a mathematical fact that an order-of-magnitude increase in velocity can mean a substantial increase in traffic and hence a tangible increase in revenue. That is, for virtually the same amount of money it would take to build a subsonic tube transport system, there would be a considerable increase in profits, along with the general benefit of more rapid delivery of people and supplies at a lower cost if the service is supersonic.

But there is another barrier, possibly the most difficult one to scale: the prejudice even scientists harbor against a wholly new paradigm—terrestrial supersonic flight. (It turns out that engineers and scientists are just as routine-prone and tradition-bound as ordinary mortals.) One renowned U.S. aeronautics authority admitted that magnetically levitated trains encased in a tube could go faster than current supersonic airplanes. "But," said he, "why would anyone want to go that fast?"

Several years ago, in my opening address to the immense throng at the International Aerospace Congress in Nagoya, Japan, I mentioned that the airplane could become obsolete on heavily traveled trunk routes "because it is too slow." The reaction of the predominantly Japanese audience was unsmiling. Nonetheless, the aircraft industry has nothing to fear from this technology. Supersonic tube flight is not the dominion of railway engineers; knowledge and design of low flying aircraft—which in essence is what the supersonic tube train is—remains in the realm of aerospace engineers. They are the logical people to develop this.

Although placing MAGLEV trains in an evacuated tube will create a new aerodynamic environment, questions about it can be answered by model tests and, eventually, a graduated program of full-scale experience. The English Channel Tunnel engineers introduced the subsea service on a step-by-step basis, and principles of safety engineering will ensure that supersonic train services are introduced conservatively. Perhaps the first supersonic trains will be limited to freight traffic; when a high level of reliability has been confirmed, passenger services will be inaugurated.

This does seem to presage a world very different from the one we are used to. But it also suggests that the future prosperity and security of the United States can, once again, be advanced by trusting the premonitions of Robert H. Goddard: If the father of rocketry could turn his attention to the improvement of tube transportation, maybe that is a valid signal for present and future leaders of aerospace, commerce, and defense. Suspend disbelief for a few moments—and look what the future can hold.

—Frank P. Davidson

LILIAN KEMP PHOTOGRAPHY

Immediately following his April 25, 1985 tube flight demonstration, Tom Stockebrand (squatting, left) uses the light-gas gun—the dark tube on the right—to shoot a Ping-Pong ball into the air, demonstrating how the ball's speed is reduced when not in a vacuum.

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Landing Rites

When I was flying combat missions in World War II, chaplains bothered me. Mostly it was because they were all indiscriminately called "Padre," which led me to expect a lot more paternalism than any chaplain could furnish.

I was first put off Army chaplains when a very young and uncertain one, assigned to the troopship that would carry 300 of us barely trained fighter pilots to the war in the Pacific, tried to make us sing as we cast off at San Francisco. His voice came over the loudspeaker, quavering with enthusiastic piety: "All right, fellows! All together now: 'Gaahd bless Amer-ri-caah...' " Not a man among us responded with anything but muttered obscenities.

When I joined my squadron in New Guinea, I met the group padres—priest, parson, and rabbi—and found them all pleasant enough. But the Protestant seemed more concerned with our bad language than with reassurances of survival or the alternative. I explored Judaism next, liked the rabbi and the singing but was baffled by the rest. As for the Catholic priest, we all got to know him because he played poker in our squadron. He was nice enough, especially when he was winning.

But fighter pilots are trained in rationality, and no padre could dig deep enough into our young psyches to ease the pressure of our real concerns. Despite the heroic work of our engineering staff, our P-39s were dying of old age. Every takeoff offered their overused Allison engines a chance to quit. Every mission was apt to be punctuated by some mechanical emergency. And if we had to bail out, we faced a sobering challenge from the tumbled green ocean of jungle.

We pilots coped with these perils in our own way. When one of us bought the farm, we would puzzle over what he had done wrong and promise ourselves we would do better. No padre could convince us that God was crammed into our cockpits, giving us useful advice like, "Don't try to take off with an overheated engine after a bad magneto check."

Since the padres had little to do for live fighter pilots, they bore down hard on proper rites for those who died. We came to dread those New Guinea funerals.

But for the group chaplains, a funeral remained one thing a man of God could really sink his teeth into. So when a guy made the mistake of spinning in, the padres would react with an efficiency that under better circumstances would have been called eagerness. They'd quickly determine the victim's religion and the proper padre would whomp up a service. Then we'd

PHIL JORDAN

have to forage in our footlockers for long pants and neckties and brush off their patina of jungle mold. Sweating rivers, we'd crowd aboard a few jeeps and jounce up to the burial ground, which always occupied a hillside. No trees grew on these rises, so without a wisp of shade we'd stand endlessly at attention under a sodden tropical sun while the padre droned on and on.

Losing a good Catholic was the worst. Putting aside thoughts of straight flushes, the Catholic padre would pull out all the stops with a high mass, at least an hour of agony. Bowed in solemnity, I would silently pray that the next one of us to die would do so quickly and painlessly and be decently cremated in his airplane.

My prayers failed. One of our P-39s quit on takeoff and provided us with our most memorable funeral. The pilot—we'll call him Ryan—augered in with a crump instead of a boom, and the medics got enough of him together to bury.

Since Ryan had been a good enough Catholic to cross himself before every takeoff, the padre felt he deserved the works. Out came long pants and ties, and down dribbled the sweat as we stood at attention, the sun beat down, and the padre droned on.

When at last the funeral dragged to an end, we tore off our neckties, opened our shirts, and clung to a jeep on its way back to the squadron. As we passed the end of a fighter strip, a P-40 roared into the air and turned straight for us. Suddenly there was a shocking silence. Its engine had quit, just like poor Ryan's. Instantly the pilot jettisoned the belly tank and the bomb-shaped 110-gallon tank sailed right at us. It struck the ground a hundred feet away, drenching us with high-octane fuel.

Back then we were all smokers, but for once not one of us had lit up. Otherwise we'd have quickly joined Ryan. Dripping and feeling sick with the stench, we paused to watch the P-40 slide onto another strip in an emergency landing. Then we roared off to our campsite.

We stripped off clothes reeking with fuel, and wearing only shorts, drove to the flightline to shower under the belly tank of water we had rigged up. As we dried off, I said, "That's the last funeral I'm going to except maybe my own. They're too damn dangerous."

"I wonder how they'd handle it back home," someone said. " 'We regret to inform you that your son blew up while attending a funeral.' " Chuckling, we drove back to our tent to open a new bottle of government-issue whiskey.

—Edwards Park

Natural Prostate Relief

It's a natural fact. If you are a male over 40 and don't already suffer from a prostate gland disorder, the odds are 2 to 1 that you will before you are 59. By the age of 65, most American men have enlarged prostates.

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SALVATION AIR CORPS

by Carl Hoffman

Photographs by Geoffrey Clifford

"It is very difficult to fly an airplane well here. But God wants us to excel at everything we do," says Rick Willms as he preflights his Cessna 185. That helps explain why, at just after dawn in one of the most remote places on Earth, he is wearing a crisp white shirt with gold captain's bars snapped to his epaulets.

A crowd of 50 silently presses so close I can feel their body heat in the cool mountain air. They couldn't care less if Willms' outfit looks professional. One man has half of a blue plastic pen stuck through a hole in his nose. Another has a stone ax resting on his shoulder. Most are naked, save the long yellow gourds that cover their penises and are tied in place with twine. We are in Korupun, in the eastern highlands of Irian Jaya, the Indonesian half of the island of New Guinea. A sweet, acrid smell of smoke and sweat fills the air. Roosters crow. Flies perch on the muddy legs of naked children huddled tightly together against the cool. Just on the other side of the steep grass runway stands a stone cairn, a memorial to a missionary eaten by angry tribesmen near here in 1968.

Willms runs his hands over the wings' leading edges and checks the flight control surfaces, the fuel, and the rake brake, a device that drags along the ground to stop the airplane. Well over six feet tall, with the big-boned build of the Mennonite farmers he was born to, he looks gigantic next to the pygmy Kimyalls, whose height averages four feet seven inches. His airplane, which takes off and lands as many as a dozen times every day on some of the world's shortest, steepest, highest, and most primitive landing strips, has spent 19,400 hours airborne, more than any other Cessna 185. It routinely carries pigs, cows, tribesmen, and crocodiles, and was once the victim of a fusillade of arrows shot by an angry mob. But, like Willms' crisp white shirt and shiny captain's bars, it looks brand new.

Willms flies for Mission Aviation Fellowship, the largest Christian flying organization in the world. So thoroughly have MAF pilots mastered the art of bush flying that, truth be told, they've squeezed the art right out of it. Diehard believer though he may be, Rick Willms relies on everything but a wing and a prayer. "Most people's image of bush pilots is reckless, seat-of-the-pants flying with the airplane door hanging by wires," says Dave Rask, Willms' boss

In the Indonesian province of Irian Jaya, mountainous terrain challenges aviators as well as gardeners. But the Missionary Aviation Fellowship pilots who serve in the region, such as Rick Willms (above), leave little to chance, with specially equipped airplanes and stringent training procedures.

In a beautiful and forbidding land, a few devout pilots put their beliefs and their skills to the test.

and MAF-Irian Jaya's chief pilot. "But that's not us."

Last year 91 MAF aircraft and 100 pilots flew nearly four million miles from bases in 18 countries to some 3,000 airstrips, more than any major airline in the world. Every four minutes, 365 days a year, an MAF aircraft takes off somewhere on the globe. That comes to more than 80,000 flights a year. MAF's single largest operation is in Irian Jaya, a place so rugged that even today a smattering of tribal groups remain uncontacted by the outside world. No roads penetrate the highlands, and MAF's aircraft remain the only access to most of the region, which has some 200 airstrips, each one hand-carved out of the mountains by missionaries and their flocks. In 1994 its 15 single-engine Cessnas and two Hughes 500C helicopters logged nearly a million miles carrying some 40,000 passengers and five million pounds of cargo.

MAF's first responsibility is to serve the churches and missionaries scattered throughout the interior. (Church personnel, produce, and livestock are charged a minimal fare.) But, always looking for income to subsidize church work, MAF will fly anybody anywhere.

"*Awas!*" shouts Willms—Indonesian for "watch out!"—as the engine roars to life. Korupun's runway begins at the foot of a mountain and ends 1,450 feet later at a sheer drop, sloping downward at a 10 percent grade. Perching at the top inside the tiny, tail-dragging 185 is like being strapped in a roller coaster poised at the crest of its first big hill. Willms pulls his MAF-regulation crash helmet over his close-cropped gray hair and, as naturally as saying grace before a meal, runs through the pre-takeoff checklist, the last part of which includes verbalizing the point on the runway where it's still safe to abort and what action to take in case of engine failure. A chicken darts across the runway. Willms is committed to takeoff only moments after he releases the brakes. Should an engine catch fire or a 300-pound pig scoot under his wheels he'll have no time to think. ("One time a pig ran onto the strip just as I was landing," says Dave Rask. "I missed him, but the chief dragged him up to me and shot him full of arrows right before my eyes, as if to teach all the other pigs a lesson.") Every MAF pilot on every takeoff recites the procedure out loud as their fingers practice dancing across the controls. "We have a much higher standard than any of the commercial companies I ever worked for," says Willms, 41, who has 11,400 hours of air time. "We feel we work in such a hostile environment that everything we can control, we do."

To that end, every airplane is equipped at MAF headquarters in Redlands, California, with a short-takeoff-and-landing kit, a global positioning navigation system, MAF-designed seats that collapse vertically to cushion the impact of a 10-G crash, the MAF-designed rake brake, which can drag the airplane to a stop in one-fourth to one-half the distance normally required, machetes and emergency rations, a unique MAF-designed emergency fuel system that is manually controlled by the pilot in case any part of the primary fuel system fails, and a cargo pod under the airplane's belly. After 1,500 hours every airplane's engine is sent back to the States or Australia for an overhaul. After 4,000 to 5,000 hours the airplane is completely stripped down and rebuilt at MAF-Irian Jaya's main base in Sentani, a city on the north coast.

MAF's airplanes often attract a flock of villagers, not necessarily because the craft are novel but because they represent a link to the outside world.

Willms throttles up and releases the wheel brakes, and the airplane starts careening down the hill. "Committed," Willms reminds himself out loud. Forty miles an hour on the bumpy, undulating

MAF hauls cargo—some of it squealing and kicking (left)—and tribesmen (right), while also serving the region's churches and missionaries. In a cozy corner of home-away-from-home, Nancy Contrucci, here with pilot husband Kent, teaches in Wamena's tiny school (below).

grass hill feels like 150. At 65 we lift off, heading straight into the side of a green mountain. Willms banks the Cessna hard to the right, and we slip down a lush tunnel of a valley dotted by wisps of ground fog. Flying in the highlands in small aircraft whose altitude is limited is a matter of snaking between mountains, not over them. In 1964 a pilot flying a missionary, his wife, and their three children beneath low clouds followed the wrong valley. When it unexpectedly ended he tried for a tight U-turn. Only the Newman family's nine-year-old son survived. With that in mind, Willms hugs the mountain wall, giving himself as much room as possible should he have to turn around suddenly.

We are bound for Boma, a village on Irian's south coast. Just 10 minutes out of Korupun the heat and humidity strikes; the world has changed. From horizon to horizon there is nothing but flat, endless miles of fetid, malarial swamps, cut with snaking rivers the color of steel. Flocks of white cockatoos surge over the jungle below. We are just 37 miles from Korupun, perhaps 120 from Jayapure, a teeming north coast city of 150,000. But below us, somewhere, are some of the last groups of people still not contacted by the outside world. Willms banks hard to the left. "There!" he shouts. We buzz a clearing; near it, there's a thatched roof sticking out of the top of a tree like some Dr. Seuss house. Figures dash into the jungle. "This area is resistant to outsiders," Willms says, "and they've had instances of cannibalism just five or six years ago. Nowadays our policy as missionaries is: If they invite us we go in, but if they don't want us we don't force ourselves on them."

Willms was drawn to missionary flying very early. "I lived near a lake in Saskatchewan, Canada, and miners used to come in and take off in floatplanes," he says. "When they went over me they'd wag their wings. Oh boy, that was it! From the time I was six or seven I wanted to be a pilot and I felt God wanted me to be a missionary. When I was 12 a missionary pilot came through our church and it just clicked; at that moment I wanted to be a missionary pilot." From then on, he says, "I was focused." By 17 he had his private pilot's license. By 18 he had his commercial license and enough money to buy an airplane. During summers he flew fire patrol out of Williams Lake in British Columbia, and he later found charter work with Athabaskan Air, flying Cessna 185s, 310s, and Twin Otters. He roughnecked on an Arctic oil rig to save money, attended Bible college, acquired his airframe-and-powerplant mechanic's license—mandatory for all MAF pilots—and finally, at age 29, came to Irian for MAF, having already flown 3,500 hours over the bush.

Willms was more focused than most MAF pilots, but not by much. Russ Wardle grew up beneath the flight path of Chicago's O'Hare; by 15 his dreams had shifted from flying for the Navy to flying as a missionary. Tom Bolser, the child of missionaries in Indonesian Borneo, grew up watching MAF pilots swoop into their jungle strips. What could com-

An MAF floatplane mingles with pirogues on a river in Boma, a village on Irian Jaya's south coast.

pare with that? Dennis Bergstrazer was already in the Air Force when he heard a missionary pilot tell his tales. "It seemed like he was talking to me," he says. Eight of the 17 pilots in Irian graduated from the Top Gun school of the missionary world: Moody Bible Institute's missionary pilot program in Elizabethton, Tennessee. And, like Willms, each flew whatever and wherever he could to accumulate the 600 flight hours required to join MAF.

Over the next two hours we land and take off repeatedly. The average MAF flight in Irian is just 20 minutes; some are as short as five minutes. We switch to a floatplane in Boma, where Willms slides the airplane down a ramp into the river. "One time I was departing with a missionary," Willms says as we taxi down the river past long dugout pirogues, "and I'd just gotten airborne when my left flap cable broke." The flap suddenly retracted, the wing dropped, dragging in the water, and the 185 flipped, nose first, into the river. *So this is what it feels like to be trapped in an airplane,* Willms remembers thinking as he stood on the instrument panel. But he and his passengers, all unhurt, crawled out the rear door. "I was treading water when the plane rolled over and sank." MAF's last casualty in Irian was in 1987, when a Twin Otter crashed on approach in poor weather, killing seven. "I've lost two good pilot friends since I came out," Willms says, "but that's one of the challenges."

We fly to Tiau, ferry a woman to a nearby village, return to Tiau to pick up a Dutch missionary, fly him to Boma, then return to Tiau for his outboard motor. Crowds standing in mud up to their knees surge around the airplane at every stop. Flies invade the stifling, cramped cabin, and Willms loads and unloads an unending array of battered cardboard boxes, shovels, bags of rice and fruit, and cans of water and fuel.

At Boma two boys stand nearby, holding intricately carved miniature airplanes. Willms has been given similar airplane models made by other boys in other villages. Indeed, in a 20th century twist, people in Irian are more familiar with airplanes than cars. "One time I flew a local guy out to Sentani and when he saw cars he couldn't believe that there were these aircraft that went down the runways and never took off!" Willms says. "When he went back they talked about it in the village for days."

By 10 a.m. we have switched planes again and are returning to Willms' home base of Wamena, in the Great Baliem Valley.

When Richard Archbold, on a bird-collecting expedition in 1938 for New York's American Museum of Natural History, spotted the Baliem (from the air, of course), he also stumbled upon the world's last great uncontacted civilization. "Never in all my experience in New Guinea have I seen anything to compare with it," he wrote. Archbold found hundreds of thousands of people living in tribes separated from one another by only a few miles, speaking completely different languages and often unaware of their neighbors' existence. Irian's interior became tabula rasa for a new kind of adventurer.

As it happened, World War II produced a bumper crop of skilled and fearless aviators, die-hard Christians among them. In 1945 three naval fliers and Betty Greene, a Women's Airforce Service Pilot (WASP) who had flown B-17s and glider towplanes, created the Christian Airmen's Missionary Fellowship. At first it was just a name; then the missionary organization Wycliff Bible Translators asked Greene for help in the jungles of southern Mexico. In 1946, out of their combined savings, CAMF bought an enclosed-cockpit Waco, which Greene flew to Mexico. Meanwhile, in England, former Royal Air Force pilots formed the Missionary Aviation Fellowship. Soon after, the two groups merged, creating Mission Aviation Fellowship, which decided to concentrate on fielding a cadre of highly skilled pilot-mechanics who could serve missions and missionaries in the farthest-flung crevices of the world.

One of the last great frontiers, Dutch West Irian, as Irian Jaya was known then, attracted flocks of western adventurers in the late 1940s and early 1950s. Anthropologists came for Stone Age tribal cultures, prospectors for gold, and missionaries for a mother lode of souls. Their quest was little different from that of missionaries centuries earlier, with one exception: Modern missionaries could fly. They came first by floatplane, landing on Irian's great rivers and then hiking inland. Sometimes they were killed by hostile tribes, sometimes hailed as gods. But always, the first thing they did was build airstrips to extend their reach. In Irian the first missionaries flew their own airplanes. But when a Sealander amphibious aircraft belonging to the Christian and Missionary Alliance crashed in 1955, killing the pilot, all Protestant missionary flying was turned over to the MAF.

The region has some 200 airstrips, all of them, including this one at Passema, painstakingly carved out of jungle-covered mountainsides by hand.

Today, no roads yet reach the Baliem Valley, and its "city," Wamena, is said to be the largest in the world supported entirely by air. It is a frontier, a place where totally different worlds and cultures are not just colliding but, for a few brief years, coexisting and intermingling. The Baliem surrounding it seems hardly changed from Archbold's time. Small compounds of thatch huts dot the valley, which is cut by the meandering Baliem River. Graceful suspension bridges cross the river. The air is clear and dry, reminiscent of New Mexico. The local tribes, called Dani, still wear little but pig grease and grass skirts or the long penis gourds. But Wamena, the interior's administrative center, is expanding rapidly, fueled by a swelling Indonesian government, outisland entrepreneurs, and western tourists. It is a startling place. At any hour, on any street corner, you will see Malay traders in stonewashed jeans and sunglasses striding next to a wide-eyed tribesman, naked save for his two-foot-long gourd, all being videotaped by a tourist, who in turn is under observation by two uniformed school girls. Meanwhile, a jet streaks off the runway just beyond.

And smack in the middle of this stew lies a slice of Our Town—albeit dressed in tropical finery. Willms and fellow pilots Dennis Bergstrazer, Len Van Wingerden, and Kent Contrucci live tucked away behind a tall hedge of verbena, just across a dusty street from MAF's hangar and offices and Wamena's runway. Neat stone paths connect three-, four-, and five-bedroom houses. The lawns are green and clipped, and dotted with tidy garden beds of daylilies, scarlet bougainvillea, and hibiscus. Bicycles lean against trees, dogs loll in the shade, and tow-headed kids dangle from jungle gyms.

Outside the compound, native men trundle by with bundles of wood on their shoulders. Inside the Willms' house it's just another North American evening. Almost. "I'm wondering if you could get me some coffee filters?" comes a voice from the kitchen.

"Is that the cone-shaped Melitas?" asks Amy Willms, Rick's wife.

"That's a copy," the speaker answers, using radio slang for "message received."

It's 4 p.m., and the wives of western pilots and missionaries throughout Irian are bantering across their radio fenceposts. Dinner is cooking on the big wood-fire stove, across the linoleum-floored room from the Kenmore microwave and refrigerator. One of the Willms' four daughters is doing homework at the dining room table. Another is curled up with a book on the living room sofa.

Flying for MAF is a career. The organization requires pilots to master high technical standards, as well as acquire an intimate knowledge of airplanes, local flying conditions, and the native language. The process takes so long and costs so much there is little pilot turnover. Pilots and their families return home for six months every three and a half years, and then they must solicit from churches and friends $4,400 to support their work for each month they're overseas. The Willms family has been in Irian for 14 years. It is more home than home, and in many ways, an idyllic place to raise a family. The community is small and close-knit. There is no crime. At the tiny school (in Wamena this year, four students in four grades), kids get more individual attention than they would at the toniest private school in the States. But, as Rick Willms admits, "There is a cost." His two teenagers, 14 and 16, attend boarding school an hour's flight away in Sentani. The oldest first left home for boarding school when she was just

The Baliem's mountain walls are a constant threat; Rick Willms hugs one as he flies to allow for a sudden turn.

A modest church at Langda (far left) stands as testament to the goal of missionaries such as Adriaan and Elfrieda Vanderbijl (with MAF's Len Van Wingerden, below) to introduce their beliefs to a culture largely unchanged over centuries (left). Yet MAF finds its secular tasks increasing. "I don't consider myself a missionary but a helicopter pilot assisting people in any way I can," Van Wingerden says.

eight. "That was incredibly difficult," says Rick. "When Amy got malaria twice in six months we went back to Canada for a year and a half for her to recover and we wanted the kids to know their grandparents and cousins and friends. But kids growing up in the field find it incredibly tough to go back to their parents' home. Our oldest didn't like it. She couldn't stand the trivial things the other girls were always talking about."

Not every MAF pilot flourishes in the confines of missionary life. At a MAF base in Bokondini I met Gary and Ann Grommet, just months away from the end of their first tour. They will not be coming back. "We've had an incredible experience here and it's really strengthened our family," Gary said as classical music played in the background. "I mean, here you have no one else. You can't choose who your friends will be. Your wife really does become your best friend. But the people who stay here for their whole careers get a bit lazy. Intellectually, it's not a very challenging life. You get up in the morning and you fly. Your housing is taken care of, your friends are taken care of. But we have brains and we're interested in the world. Our children need stimulation. It's time to move on."

Just weeks before, their 10-month-old son, Alex, stopped eating and was racked with diarrhea and vomiting. He couldn't stand up. "I got on the radio with the doctor and it turned out he had malaria. He was a day away from dying. I could fly him to the hospital, but what about the others? We fly medical evacuation all the time, but still so many people die out here. Angela, our four-year-old, always says, as soon as someone is sick, 'Are they going to die?' She's seen so much of it. Just last night Alex threw up and she said, 'Is Alex going

to die?' And if he had been a village kid he might have. Can you imagine sitting there all night and watching your child die and being able to do nothing about it? That's the secret fear we live with."

I wake with a start at 4 a.m., bobbing gently on the Naugahyde waterbed in the Willms' guest room. There's a cacophony of roosters crowing, feral dogs barking. By five, the crowds and their battered boxes, bundles of odd leaves, and soiled bags are lined up outside MAF's office and hangar across the street, pressing for a look at the day's schedule. On the flightline, the four Cessnas based in Wamena are already being loaded and preflighted. Here in the highlands, afternoon clouds shroud peaks rising to 16,000 feet, and winds whip through narrow mountain valleys and across precipitous airstrips. When the weather is good, it is good at dawn and the hours immediately after; MAF pilots fly at first light and are often home by noon.

By 5:30 all four airplanes are up and away. I am bound for Korubaga with Tom Bolser, at 29 MAF's youngest pilot in Irian and its only bachelor. As we slide over the valley, puffs of smoke rise from conical huts into the silvery light. "On beautiful mornings like today I think, *Wow, they actually pay me to do this!*" he says. Bolser is short and deeply tanned, a younger, darker version of comedian Jay Leno. He grew up in Borneo, attended Christian boarding school in Malaysia, and graduated from Moody. At the end of its five-year program, which includes two years of Bible study and theology, students graduate with licenses as commercial pilots and mechanics. Bolser graduated in 1989, worked for a year to pay off college debts (except for fuel and aircraft rental costs, Moody is tuition-free), spent a year lining up donations for his support, and came to Irian in 1991.

Like young pilots everywhere, Bolser takes every flight MAF will give him, flying 80 hours a month—the maximum allowed by Indonesian law. (In the United States, the Federal Aviation Administration allows pilots of commuter aircraft 120 hours a month.) Yet despite the 2,700 hours of air time he's accumulated since coming to Irian, there remain dozens of strips he can't yet fly onto, so stringent is MAF's pilot check-out procedure. To be cleared for a strip, every pilot must make five landings on it with an instructor pilot. For the 200 strips on Irian, the process can take years.

In 21 minutes we're over Korubaga. As MAF regulations require, Bolser circles the strip once, making sure the runway is clear and letting the village know he's coming in. As we land, I notice a new-looking split-wood fence surrounding the strip. "Not long ago I almost hit a goat coming in here," Bolser says. "It passed right under my wing. We closed the strip down and said we wouldn't fly in until they built a fence." Before the usual crowd of onlookers, he unloads drums of kerosene, cooking oil, rolls of chicken wire, a half-dozen cardboard boxes. In go burlap sacks of coffee and two passengers, and we're off to Wamena again.

"I've carried pigs that weigh 250

Incongruent pairings of the Stone Age and the modern are a frequent sight as Irian villagers embrace the outside world (above right). In Pelian (above left), Adriaan Vanderbijl takes measurements for a much-hoped-for runway; at another missionary's home, two members of the Kimyall tribe help translate the New Testament into the local language (left).

pounds and, boy, you've got to strap those down good, with their feet in the air so they can't kick anything," Bolser says. "When big ones are in the pod fussing you can feel the airplane shake. I've carried 200 crocodiles in burlap bags. You look back and the bag is wiggling. When you fly nationals the big question is always: Does the penis gourd go in front of the seat belt or behind? I had one guy sit up front and his gourd was sticking right into my yoke. I finally said to the local strip agent, 'You figure this out.' I came back and he had it tucked away somewhere."

Today, western Christian missionaries find entrance to the country with the world's largest Moslem population increasingly restricted. Indonesia has sharply reduced its allocation of missionary visas, and just 10 western missionaries remain at the 100 Protestant strips and mission stations in the eastern half of Irian. The local evangelists and pastors who replace them lack the big budgets of their western counterparts, budgets that have traditionally helped pay for MAF flights. And yet MAF finds its role expanding. Its strips, its aircraft, and its pilots with their thousands of hours of experience represent an extraordinary, as yet irreplaceable infrastructure for the region. So MAF finds itself performing more and more secular tasks, from disaster relief to medical evacuation to shuttling local government officials to supplying routine transportation. It is, perhaps, a shift from the support of Christian missionaries to simple Christian support.

Anyone locked on an image of Bible-thumping pilots need only spend a day with Len Van Wingerden.

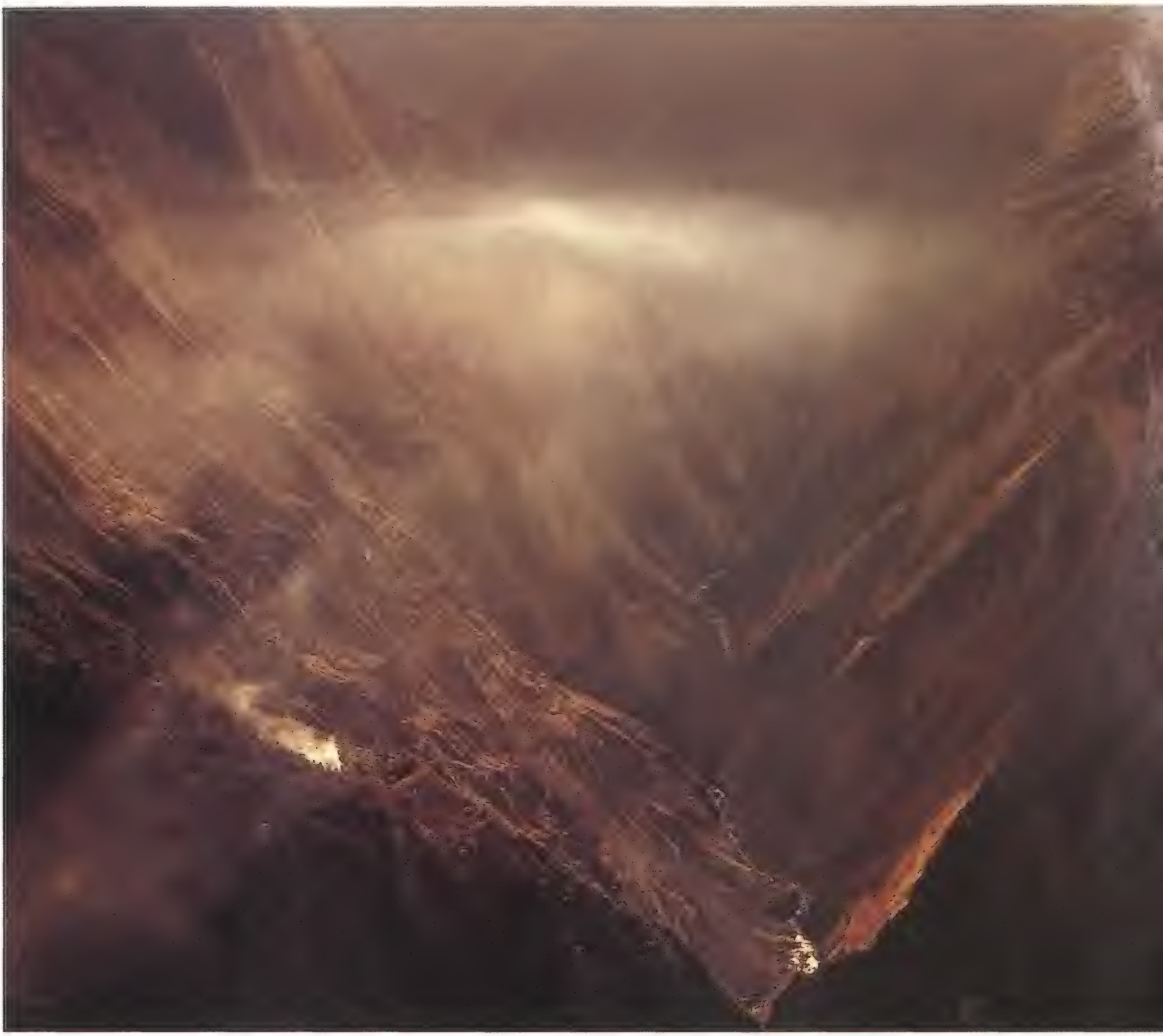
"I don't consider myself a missionary but a helicopter pilot assisting people in any way I can," Van Wingerden says as we skim over sharp mountain ridges at 11,000 feet in one of MAF's two Hughes 500C helicopters. Tan and fine-featured with intense hazel eyes, he looks like a movie star pilot in his blue flightsuit and cowboy boots. We cut through the saddles of high ridges, zipping over isolated huts almost impossibly perched on mountaintops on our way toward Mbua and the Wosak valley, a region so steep and high it can't be reached by airplane. We are to ferry a Dutch missionary and his wife, a nurse, to a church and clinic they haven't seen for three years in the remote village of Mbambisik.

Van Wingerden speaks fluent French, Dutch, German, English, and Indonesian. Before coming to Irian six years ago, he flew helicopters for Federal Express in Los Angeles. To me, he seems the perfect Christian: he's filled with commitment, conviction—and doubt. "I was brought up in a Christian home, but also a very wealthy home," he says. "I felt like there were too many needs

Villagers toting building poles fall in step behind pilot Russ Wardle at the dirt airstrip at Langda.

in the world and that with everything I had I should go somewhere—anywhere—and make a small contribution." He checks his navigation equipment as we soar over terraces of sweet potato on hillsides so steep that gardeners occasionally fall off and break bones. "Honestly, there are times when I think everyone has a right to his own personal conviction or beliefs. There are times when I wonder, just because I have a personal conviction, why should I push my beliefs? These people are free in their own environment and I wonder: Is it right to disturb them? But we're not out here slinging Bibles. My personal religious convictions say it's important to help in any way, and I love flying helicopters. Just the medical side has made such a difference. I flew out a woman struggling to deliver twins. When I brought them all back it was like a miracle to the village, because in the past in this environment they all would have died. When you bring them back to their villages it's incredible to see how thrilled they are to come home."

We land at Mbua, home to missionary Adriaan Vanderbijl and his wife Elfrieda. Since 1963 they've opened up eight airstrips, 12 churches, six primary schools, and 31 clinics in the surrounding valleys. Into the helicopter go a generator, a radio, medical supplies, a soccer ball, cooking supplies, jerry cans of water, and boxes of food. In just minutes we're up again, cutting over jagged, forested mountainsides that drop three and four thousand feet before veering upward again. On Van Wingerden's knees is a hand-drawn map of the Wosak valley, with Mbambisik identified as



"Foxtrot 41." The flight takes 10 minutes; before the helicopter was available Adriaan Vanderbijl walked, undertaking journeys throughout the valleys that took days. On a rocky hillside stand a smattering of huts and two small wooden buildings, the clinic and church. On this trip Adriaan and Elfrieda will spend four days at Mbambisik, ministering to its peoples' bodies and souls. "*Awas, Awas,*" Van Wingerden shouts to the children, women in grass skirts (on one I spot a tattered T-shirt reading "Beverly Hills 90210"), and men in gourds surging toward the thundering helicopter. Children scream, men stare.

Save for a lone Cessna, the Grand Baliem Valley looks like a land untouched by time.

Leaving Elfrieda and the gear, we take off again, this time for a quick look at a nearby place called Pelian, whose people have been trying to build an airstrip for five years. The wind is picking up, buffeting the little helicopter, and small, gray clouds are starting to cover nearby mountain peaks. "We've got to hurry," Van Wingerden says. We slip through a valley, round a mountain wall, and three minutes later land on Pelian's so-called airstrip.

We are 7,000 feet up, squeezed between a cliff and a mountain. We climb out of the helo like invaders from another planet. Here, almost no one has even the tattered remains of western clothing. There is no school. No clinic. No store. No church. Not a western-style building stands. Men with bows and arrows and stone axes resting on their shoulders stare from afar; a hundred women and children and a few men press upon Van Wingerden and Vanderbijl. The strip has been cleared of trees but is rutted and filled with stumps, rocks, and boulders the size of station wagons. A bonfire glows over one; I can feel its heat 30 feet away. "The only way they can move the boulders," says Van Wingerden, "is to make them so hot they crack into small pieces."

Followed by the huge crowd Vanderbijl measures the strip's length. Already the whole village has moved itself a hundred yards to the side to give more space. But from the top, hard against a mountain wall, to the cliff, is just 850 feet. "At this altitude they'll need at least 1,500 feet for a Cessna," Van Wingerden says. For the next 20 minutes he and Vanderbijl and the crowd argue, Van Wingerden standing atop a boulder in his cowboy boots. In a sense, Pelian's future is in his hands. "Who's in charge here?" shouts Van Wingerden to Vanderbijl, who translates. "Last time I was here I made it clear that they've got to slide the runway over a bit; they're running right into the mountain," the pilot says. But the argument

American missionary Orin Kidd strolls outside his Korupun home with a young member of the Kimyall tribe.

continues, the villagers passionately pressing Van Wingerden. "They've already moved the village," Vanderbijl tells him.

Van Wingerden looks at the sky, his face to the wind. "I'm watching the weather and we've got to get out of here," he says. We pile into the helicopter and lift away, clouds of dust and sticks flying into the inscrutable faces and fanning the coals and smoke of the burning rock.

What the missionaries started 40 years ago has come full circle. Vanderbijl has never before visited Pelian, and no missionary or MAF person has goaded the village to make an airstrip. But a few villagers have walked to Wamena. They know of the outside world. And they want it to come to them. Desperately.

"They're going to fight for what they can get," Van Wingerden says after we drop Vanderbijl off again at Mbambisik and squeak over a 13,000-foot peak. "Once they get a strip the Indonesian government will come in and set up a post, maybe even a school. They kept telling me 800 feet is enough. I kept saying it was impossible. You try to be encouraging, but you don't want to give them false hope. I was here two years ago and they haven't made too much progress. I kept saying, 'Look, you've got a mountain right there.' But they just said they'd move it."

COMMENTARY:

The Kindest Cut

Everywhere I go, it seems, my friends and colleagues in the aerospace community are depressed. NASA's budget is shrinking and military spending is flat. They talk as though the world they know is ending and wonder about the future of aerospace.

In fact, smaller budgets could be the best thing to happen to aerospace in some time. But rather than just nibbling at the edges, the Deficit Hawks of Congress need to make the kinds of budget cuts that kill programs and close offices. Such deep cuts would not only help reduce the federal budget deficit; in the long run, they might even be a net benefit for U.S. space technology.

This may seem like an example of "voodoo economics"—spend less, get more—but there is a good amount of reasoning and evidence to support it. In reality, some of the most important innovations in aerospace have occurred during periods when spending on research and development was flat or even falling: Cockpit instrumentation in the 1930s is one example; satellite navigation in the 1970s is another.

This is because R&D is relatively cheap. The largest costs of an aerospace project are incurred when the program enters full-scale series production. The early phases—when new technology is actually developed and demonstrated—usually account for only 10 to 15 percent of the total cost of the project. Basic research—combustion science, materials research, developing new software concepts—is even cheaper. R&D requires some money but not a lot.

Indeed, many people might be surprised to learn that NASA—an agency whose main mission is supposedly research and development—spends only $9.5 billion of its current $14.2 billion annual budget on R&D. The rest, which even the government does not classify as R&D, is spent on operations, maintaining the space shuttle, administration, and infrastructure.

So it's clear we can support an aggressive R&D effort even while we trim the budget. Yet one could take the argument a step further. In the long run, cutbacks in space programs could actually accelerate the state of the art.

Giant steps in technology—the kinds of leaps that aerospace saw in the 1950s with the development of jet propulsion and rocket systems—require at least two conditions. One is that there need to be good ideas waiting to be exploited, as was the case just after World War II, when the aerospace community could easily see the potential of jet engines and long-range missiles. The second is that innovative people need to have a clear field on which to run. Someone needs to tame the research bureaucracy, which squelches radical innovation, or better yet, the field needs to be so new that bureaucracies have not yet had a chance to take root.

Left to their own devices, bureaucracies—and make no mistake, the government's aerospace community is a collection of bureaucracies—keep to a steady, predictable course. Indeed, this is why we like big, staid bureaucracies to be in charge of things like airline safety, for which reliability is all-important. The Federal Aviation Administration may use computer technology that is 20 years behind the times, but you don't see too many airliner crashes. The FAA is rigid, inefficient, and uncompromising, and people who fly a lot should like it that way.

Alas, once a bureaucracy has been around for a while, often nothing short of an explosive charge can get it to change course. This may be okay in the case of the FAA, but it can be disastrous if an organization needs to be flexible and innovative, as aerospace R&D requires.

This, at least in part, may explain why innovation in aerospace research and development—space technology in particular—has been slowing down. Organizations in the R&D community have staked out their territories and settled into their own orthodoxies for research priorities and design philosophies. Ideas that don't fit the current program are labeled "offbeat," "un-

Bruce D. Berkowitz explains why big budget cuts may be just what aerospace research needs to fuel new ideas.

proven," or "leapfrog technologies."

It's not that NASA or Department of Defense officials are unusually parochial or narrow-minded. It's just that the same attributes that make mature bureaucracies efficient in some areas, such as reliably carrying out routine operations, make them ill-suited for other tasks, such as taking risks and questioning conventional wisdom.

There are basically two schools of thought on how to get organizations to generate new ideas and new ways of doing business. The first is to encourage (or compel) an organization to change its mindset and its way of doing business. The second assumes that a mature bureaucracy will not change its thinking on its own, leaving two alternatives: thoroughly shaking up the organization from the outside or giving other organizations an opportunity to compete.

The first approach is the one Daniel Goldin has been trying for the past three years at NASA, pushing the agency to work "faster, better, cheaper." Unfortunately, experience suggests that changing a bureaucracy's way of doing business may be one of the hardest tasks in the world. There are usually too many people within a large organization with too much invested in their education and experience to suddenly change direction. And these attitudes are reinforced by formal procedures and rules.

What's more, such organizations can be remarkably resilient. They may change at the margins but keep as much "business as usual" as they can. Recall the U.S. auto industry during the 1970s, for example. Detroit was beginning to face stiffer competition from Japan, which had figured out that there was a market in America for low-priced, well-built small cars. U.S. companies, which had prospered for decades building big, unsophisticated turnpike cruisers, resisted. When pushed, Detroit would build smaller, more efficient cars (often with tragi-comic results, like the Pacer and Vega), but its heart was in selling Impalas.

The Deficit Hawks of Congress need to make the kinds of budget cuts that kill programs and close offices.

Similarly, in response to its critics, NASA is undertaking new programs like the Small Satellite Technology Initiative and the New Millennium program for building cheaper space probes (total budget for the 1996 fiscal year: about $30 million each). But its priority is still mega-projects like the space station (total FY 1996 budget: $1.8 billion) and keeping the space shuttle flying (total FY 1996 budget: $3.2 billion). NASA's culture is manned space and big projects. In other words, Impalas.

Of course, NASA is a favorite target for criticism these days, but in truth, the aerospace community as a whole has grown grayer and slower. For example, in 1956 the Air Force could develop the Thor intermediate-range ballistic missile (the forerunner of today's Delta launch vehicle) in just 13 months. Today the Department of Defense is spending 18 months just to decide what kind of launch vehicle the United States should develop next!

This is why the second approach to generating new ideas seems to have the most potential: Change the very organization itself, or look for a new one. Alas, in the case of bureaucracies like the aerospace community, the most effective tool for bringing about such changes may be massive budget cuts.

The private sector has lots of ways to shake up organizations and eliminate those that refuse to adapt. For example, in the case of General Motors, after a series of failures and fiascoes in developing a car to compete with Toyota and Nissan, the board of directors finally fired the management and moved the company out of its long-established headquarters in downtown Detroit to the Detroit suburbs. Private companies can also sell off entire divisions that no longer fit their market strategy (one reason why General Electric no longer makes satellites). They can take over companies to acquire new talent (à la IBM and Lotus Development) or merge to develop synergy (Northrop Grumman, Lockheed Martin, etc., etc.). Or, if they really screw up, they can simply go out of business (Pan Am, Eastern Airlines).

Even in the political world, there is a ready means to replace organizations in order to introduce new ideas and new thinking. Ask George Bush. Ask Tom Foley.

Not so with bureaucracies like NASA and DOD. Government agencies do not have to deal with a competitive market

A former staff member of the U.S. Senate Select Committee on Intelligence and an adjunct professor in the Department of Engineering and Public Policy at Carnegie Mellon University, the author writes frequently about issues in technology development.

or elections. They are insulated from such pressures by political patrons, special interests, and civil service protection. So another, more Shermanesque approach is necessary.

Mancur Olson, an economist at the University of Maryland, published a book a few years ago, *The Rise and Decline of Nations*, in which he noted that virtually all governments became moribund over time. The notable exceptions, he discovered, were countries such as Germany and Japan, which had lost major wars. Olson concluded that losing a war and experiencing the total uprooting of one's government had the unexpected benefit of dislodging special interest groups and bureaucracies that had grown inefficient and complacent.

Since we can't very well send a flight of B-29s to NASA headquarters on a mission to "streamline" its bureaucracy and inject some competition, the best solution may be the massive budget cuts proposed by House Budget Committee Chairman John Kasich and his fellow Deficit Hawks.

Halfhearted cuts of, say, one or two billion per year would not work. Indeed, they could be counterproductive, because the small, innovative programs that NASA and DOD have undertaken would be the most vulnerable to being lopped off. We need to be more aggressive.

For example, imagine for a moment what would happen if we cut back NASA's budget by about 30 percent—to $10 billion. We would not be able to meet the target just by eliminating the small programs. We would be forced to cancel the space station. We might even have to ground the shuttle.

On the other hand, we would also free up several billion dollars more each year to spend on more productive R&D and technology development. Once we kill the dinosaurs, we could foster more competition by spreading smaller amounts of money over a larger number of organizations—including some from outside the current establishment.

Consider some of the opportunities. An all-out test program for hybrid rocket motors could be completed for about $80 million. A program to develop a lower-cost, low-pollution solid rocket motor could cost about the same. Low-cost, high-payoff probes and satellites like Lewis, Clark, Lunar Prospector, and Mars Explorer go for about $50 to $150 million each; we could, in effect, double or even triple Goldin's New Millennium effort.

Some of the most important innovations in aerospace have occurred during periods when spending on research and development was flat or even falling.

At the higher end of the scale, we could support a wider variety of approaches to reduce launch costs. For instance, NASA now spends about $170 million to support three teams developing single-stage-to-orbit vehicle concepts; probably only one team will get the chance to build a prototype. By flying less now, we could support a broader-based SSTO effort and still have enough left over to fund other launch concepts, such as two-stage-to-orbit vehicles and low-cost expendables.

Now ask yourself: Which would produce more science—flying a few shuttle missions each year or launching hordes of low-cost probes and satellites? Which would have the greater long-run effect on space technology—building a manned space station or deferring the station and using the funds to develop the technologies necessary for truly economical launch vehicles? By canceling high-profile programs today, we could redirect the money and lay the groundwork for a new golden age of space exploration in, say, 2005.

Naturally the current aerospace establishment will loathe those options. Bureaucracies always want to keep the status quo. The agencies will argue that they are too important to cut, and they will lobby to protect existing programs. That's why Congress must act.

Ironically, despite the cries over budget cuts in aerospace, most reductions so far are just promises for future years. For example, this year the space station flew through Congress, supported by newly minted Republican legislators who were elected because they had pledged to take the knife to federal spending. Some observers credited the good feelings produced by the movie *Apollo 13*—ironic, considering that the improvisational, rough-and-ready approach depicted in the film is exactly the opposite of the current operating mode typical in NASA and most of the aerospace community today. (Will we ever see a Ron Howard film in which Tom Hanks plays a GS-15 employee in a two-day source selection meeting for a $500,000 contract?)

The current budget crisis gives us a chance to shake the trees and trim the undergrowth in the aerospace community. We need to make the most of the opportunity. So go for the gusto. Take a big bite.

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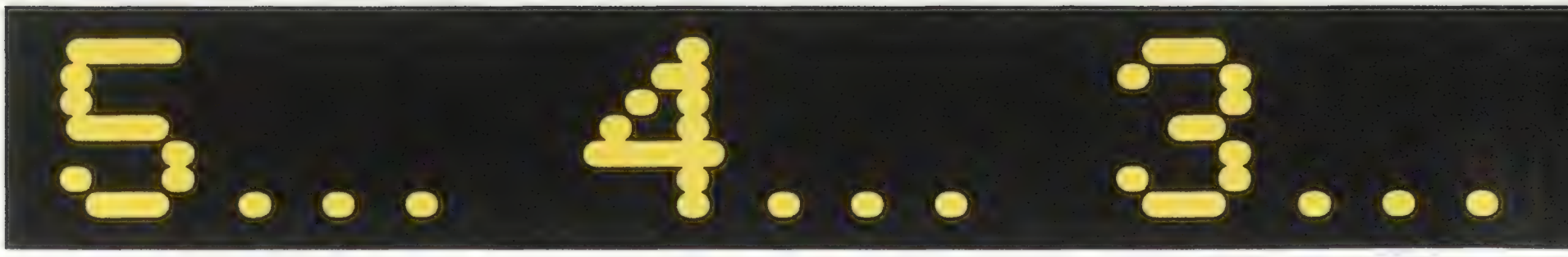


On his first space shuttle mission, astronaut Daniel W. Bursch was mildly surprised by the violence of the main engine firing. Bursch, a Navy commander and test pilot, describes a sensation that the shuttle simulator couldn't quite replicate. "It really does feel like these engines are strapped to your back," he says. "On the pad the engines create a lot of noise, a lot of vibration. You can almost feel the shock waves as they develop out of the engine." Bursch's biggest surprise of the day, however, came seconds later, when the engines shut down.

His first reaction was disbelief. "The first thing that catches your attention is the master alarm," he remembers. "It's very loud and it's obvious that something's wrong. Five to ten seconds after it's happened, all the noise has gone away, all the vibration. There's a slight rocking of the vehicle. It's really hard to feel it, but the vehicle continues to sway back and forth."

It has happened only five times in shuttle history: The three main engines on the orbiter ignite, computers monitoring them detect a problem, and the space shuttle onboard computers shut the engines down. June 26, 1984: A main fuel valve actuator in one of the engines stuck. July 12, 1985: A chamber coolant valve refused to close. March 22, 1993: An oxidizer purge valve jammed on a chunk of O-ring. August 12, 1993: A faulty sensor indicated abnormal fuel flow. And, almost exactly a year later, less than two seconds before the solid rockets were to ignite, an oxidizer pump overheated. "We are not willing to lift off if we lose redundancy before we get to T-zero," says John B. Plowden, who manages the Rocketdyne team that services the shuttle's main engines. "That's the way the system is designed."

The T-zero event is the ignition of the solid rocket boosters, propellant-filled towers that generate 71 percent of the thrust the shuttle needs to leave the ground. "When those SRBs light, there is no recall," says Bruce Bartolini, a launch team manager with Lockheed Martin Space Operations. "You're going flying." The liquid-fuel engines ignite 6.6 seconds earlier than the solids, giving the computers a narrow window in which to call off the launch.

"There's too much stuff going on in too short a time for a human being to make a decision and then take action," Bartolini says. Fifty times a second, a computer on each of the three main engines examines close to 30 critical parameters, including sensor function, fuel pressures, temperature, vibration, fuel flow rates, and power status. If all three engines reach 90 percent of maximum thrust by T minus three seconds and all parameters are within limits at T minus zero, the shuttle computers send out commands for pyrotechnics to ignite the SRBs, split the bolts holding the shuttle to the pad, and release the umbilical cord to the external tank.

2... ABORT

SCOTT ANDREWS (4)

When a space shuttle shuts down in the last seconds before liftoff, the launch team has its most important work to do.

by Gregory Freiherr

If certain limits are exceeded, the computers command an abort.

A launch pad abort is a safety measure, but it creates a whole new set of problems since it leaves an enormous amount of potential chemical energy sitting on the pad. "The real key to handling an emergency as serious as an engine abort is practice," says Bartolini. "You have to know your procedures, and you have to be willing to execute them. In other words, you can't sit there and say 'I hope this never happens. I don't want to ever have to do that.' It's just like flying airplanes. You have normal and emergency procedures, and you better know your emergency procedures or you're not going to be doing the normal ones for very long."

To keep the launch teams in practice, NASA runs a series of simulations at the Kennedy Space Center in Florida, similar to the mission simulations that train astronauts in Houston. Although the space shuttle countdown is governed by a checklist that fills five volumes and takes three and a half days to execute, the principal training simulation begins at T minus 20 minutes, the point in the countdown when the ground computer network gives the first commands to the computers on the orbiter. (This interaction continues until T minus 31 seconds, when the ground computers hand off the launch sequence to the onboard computers.) Several simulations are run before every launch; the final dress rehearsal, known as the Terminal Countdown Demonstration Test, includes putting the flight crew members on the orbiter and getting them out again. The test always ends with an abort after main engine ignition.

One of the first things you notice about the firing room, where the engineers sit during launch, is its impersonality. There are no family photographs, no kids' drawings taped to the consoles, no cartoons stuck on the side of a computer screen, no houseplants, no newspapers, no note pads. It's as naked as a hospital operating room. When this observation is mentioned to Al Sofge (pronounced SOF-gee), NASA assistant launch director, he shoots back sternly, "This is the firing room. This is where we launch rocketships." After an instant, he adds, "Dan Marino doesn't have a picture of his kid taped to the side of his helmet."

Sofge's football metaphor is apt. The law of the firing room is concentration; its most frequent activity is drill. Although the room's windows provide a view of the launch pad, the launch team members rarely see a shuttle liftoff. They read its status in the numbers on their computer screens.

The firing room looks a lot like mission control, its sister control room in Houston, which takes over from Florida as soon as the shuttle's solid rocket boosters ignite. Banks of gray metal consoles with computer screens fill the basketball court-size room. On each bank of consoles there is a cryptic nameplate: HAZ GAS (hazardous gases), LOX SYS (liquid oxygen system), MPS/SSME (main propulsion systems/space shuttle main engines). About 200 engineers sit at the consoles, immersed in the illusion of a shuttle countdown. The training goal is to make

On March 22, 1993, when space shuttle computers sensed that the ignition of main engine number three was incomplete, they kept STS-55 on the ground.

the monitors look exactly as they would if a real launch were under way. The engineers report to the NASA Test Director (NTD) and the Orbiter Test Conductor (OTC), who communicate with the flight crew on the shuttle.

"The last command we give the astronaut flight crew is at two minutes and 30 seconds," says Bartolini. At that point the shuttle begins running solely on internal power, and the OTC tells the astronauts to close and lock their visors and initiate oxygen flow. "He usually gives them a little send-off, and then it gets real quiet. The only talking that's being done is by the ground launch sequencer engineer calling out the different milestones as we go on down and the NTD, who starts calling at one minute, then 45 seconds... on down. Other than that the firing room is extremely quiet. Everybody is looking at their data hoping that they don't get an anomaly."

In today's simulation, everyone gets plenty of anomalies. Data systems engineer Robert Pierce and two math modeling colleagues have loaded the computers with a variety of virtual emergencies. "We're really taking a polished team and putting a high gloss on it," Pierce says. "We plan for things that have a likely occurrence of happening. 'Likely' for us space nuts is less than one percent. We don't like surprises."

Many of the problems Pierce and his gremlins throw at the launch team occur during a pad abort. After the orbiter's computers command a main engine cutoff, they grind through the procedures for safing the vehicle: starting a spray of water to disperse unburned hydrogen exhausted from the main engines, for example, sealing the hydrogen and oxygen valves to the engines, disarming the explosive bolts on the solid rockets. Progress is reflected on computer screens filled with blue, green, yellow, and—to show exceeded limits or other trouble—red or flashing numbers. The red numbers require engineers to respond according to well-documented procedures.

In one simulated emergency, engineers begin to see temperatures in red because the shuttle's ground cooling unit fails. "You don't want to cook your equipment," Pierce explains. The NTD issues an order to activate backup systems, then another to shut down a series of electronic systems on the shuttle that produce heat. An engineer at the environmental control console manually flips a switch to turn on a chilled-water heat exchanger. Others activate radiators on the inside of the payload bay doors. At another environmental control console, a team lowers the temperature of air being pumped into the payload bay by a purge system.

Next, the NTD orders staff at the LOX and liquid hydrogen consoles to prepare to drain the external tank, a precaution in case power to the shuttle must be turned off. The next step is to reestablish power from the ground in order to shut down the onboard fuel cells, which are major heat generators.

"Then we have a decision point," Pierce says. "Are we still hot?" If so, members of the launch team will continue to turn off the shuttle's various systems. Throughout the process, the NTD is getting updates on temperatures from environmental control engineers. If the temperature doesn't drop to an acceptable range, he will order an emergency power-down and get the crew off the shuttle. Without electrical power on the shuttle, the launch crew no longer sees

RICH MAYS (5)

An astronaut rehearses the trip across the shuttle access arm, which retracts seven minutes before launch but swings back automatically in case of a pad abort.

data from its systems, a situation that would require an emergency egress for the flight crew. "They open the hatch, jump out, run across the arm, and do the slide wire thing," Pierce says.

"The slide wire thing" is the astronauts' escape system: seven flat-bottom baskets that slide down 1,200-foot wires to safety. Each basket is made of steel and heat-resistant fiber surrounded by netting and can carry up to three persons. They slide down wires into catch nets, which drag chains to stop them near a bunker designed to withstand the force of a shuttle explosion.

In a real emergency, the astronauts would take a brisk walk—no more than 50 feet—across the shuttle access arm and fixed service structure to the baskets. Their trip would be complicated by a steady stream of water being sprayed to protect them from flames or heat. To ensure that no one gets lost, crew members are trained to grab a mitt full of each other's spacesuits. A crew of five, for example, splits into groups of two and three. They would follow a "yellow brick road"—gold and black chevrons painted on the metal grate floor—aiming them toward the baskets.

Riding the slide wires has its own risks—ones serious enough that during the abort simulations NASA fills the baskets with weights and dummies rather than people. But the agency has man-rated the system. George Hoggard, a training officer on the pad rescue team, is one of only three people who have ever ridden in a slide-wire basket at the launch pad. The ride began 195 feet above the ground and ended 21 seconds later. The basket reached 53 mph before striking the net.

The only part of the ride Hoggard found unnerving came near the end, when the basket slapped the restrain-

Opposite, top: An escape down the slide wire begins 195 feet above the ground and ends 1,200 feet away from the fixed service structure (above).

Below: George Hoggard gives M113 driving tips to astronaut James Newman, and crewmate James Voss checks out the sun roof.

NASA (C)

In the Launch Control Complex firing room, 200 engineers monitor the shuttle's health as the clock counts down. Opposite: Endeavour *returns to the Vehicle Assembly Building to have its engines replaced after its launch was aborted in August 1994.*

ing net with a bang. "It was like a shotgun going off," Hoggard says. "But nothing hurt, so I figured I was still okay." The net and drag chain broke free from their poles, as they were designed to do, and the chain dragged through sand to bring the basket to a gradual stop.

The bunker, located about 30 feet from the end of the slide wire, is stocked with water, oxygen, and medical supplies. But if one of the crew is hurt and needs more than first aid, an M113 armored personnel carrier, parked next to the bunker, can be used to get the astronaut to any of several points for evacuation by helicopter.

Several weeks before scheduled liftoff, the crew members take turns driving the M113, an acquired skill. It takes only a minor miscalculation to make a big mistake, as an astronaut discovered last spring when she took a corner too sharply and drove the M113 into a pond behind one of the launch pads.

The exercise isn't designed to turn astronauts into tank drivers; it's part of building a team, says Captain David M. Walker, four-time space veteran and commander of the five-member STS-69 crew, which was launched on September 7. "It gives us a chance to interact with the fire and rescue people, who are going to be the folks who save our bacon if something goes really wrong," he says.

The astronauts practice emergency egress primarily at the Manned Space Flight Center in Houston. The fastest a crew has evacuated the shuttle mockup there is about two minutes. The exercise begins with a flurry of disconnecting—seat straps, oxygen lines, and communications cords—and culminates with a struggle to get out of a single hatch wearing a full pressure suit saddled with a parachute and life raft. Engineers in the firing room are taught to be ready to override switches accidentally tripped as the astronauts clamber out of their seats. During simulations at Houston, the astronauts wear old helmets because the visors are commonly scratched and cracked from banging into the mockup's instrument panels and bulkheads.

Emergency egress is a last resort. Experience has shown that engine shutdown does not require an egress. "In fact, until we really understand what kind of situation we have outside, many times the safest place for [the crew] is inside with the hatch closed," Al Sofge says. "We could egress the crew into a worse situation than they're in. For example, if you had a hypergolic tank rupture on you and you had a large hypergolic cloud and that's the only problem you have, and your cloud covers the egress route, you may be better off leaving them in the vehicle."

In addition, the flight crew works during a pad abort, at least initially, switching off the auxiliary power units, disarming the reaction control system and orbital maneuvering system, and, most importantly, shutting down the backup flight software. The most recent abort, on mission STS-68, occurred so close to launch that the backup computer began counting up, as though the shuttle had launched. If the computer had not been shut down, the explosive bolts on the solid rockets might have blown at the one-minute 40-second mark, when the SRBs normally separate from the vehicle in flight. The solid rockets hold the shuttle and external tank upright on the pad. Blow those bolts and the tank and shuttle fall over.

Engineers in the launch control center are especially on guard for signs of conditions that could lead to fire or explosion, such as bubbles in the umbilical line that feeds oxygen to the main engines. To remain liquid, oxygen must be kept at –298 degrees Fahrenheit. During an emergency shutdown of the main engines, some of the oxygen being pumped to the engines could warm

and begin to boil, creating a bubble that could back up through the plumbing and into the external tank. In the process, that bubble would create a void in the 100-foot line leading to the shuttle engines. "When it bursts at the top of the tank, the LOX [liquid oxygen] will come rushing back into the line leading to the shuttle," says John Sterritt, a Lockheed Martin engineer who leads a team of propulsion experts in the firing room. The sudden pressure could cause the external tank to fail, "like popping a paper bag," he says. "With any kind of ignition source, you'd have a real potential for fire." So Sterritt and his team carefully watch data streams that would indicate heating in the oxygen umbilical.

All the years of practice, as well as the experience of five pad aborts, have made safing the shuttle almost routine. "The procedures have all been refined; the little discrepancies we noticed in the beginning of the program were changed and tested and put in place," says Greg Katnik, lead flight structures engineer for NASA. Katnik was an engineer in the firing room 11 years ago when a hydrogen leak caused flames to lick up the east side of the shuttle during the first abort. The launch team manually turned on the Firex water system to disperse the hydrogen and put out the fire. Since then, NASA has programmed its computers to trigger the water system at the start of a pad abort. An engineer on the launch team also pushes a backup button to make sure the engine is flooded with water. Steel plates have been installed under the access arm to keep flames from reaching the astronauts in case they have to cross to the slide-wire baskets.

After an abort, the critical safing procedures take about 10 minutes, according to Bruce Bartolini. "You then launch into several other sequences which get everything secured and get the crew out. So we're really done about 45 minutes after the abort.

"We're prepared for the emergencies," Bartolini says. "I myself, after I give my last command [at] about two minutes, I have my checklist tabbed, and I turn to the abort procedure and I'm ready to do it."

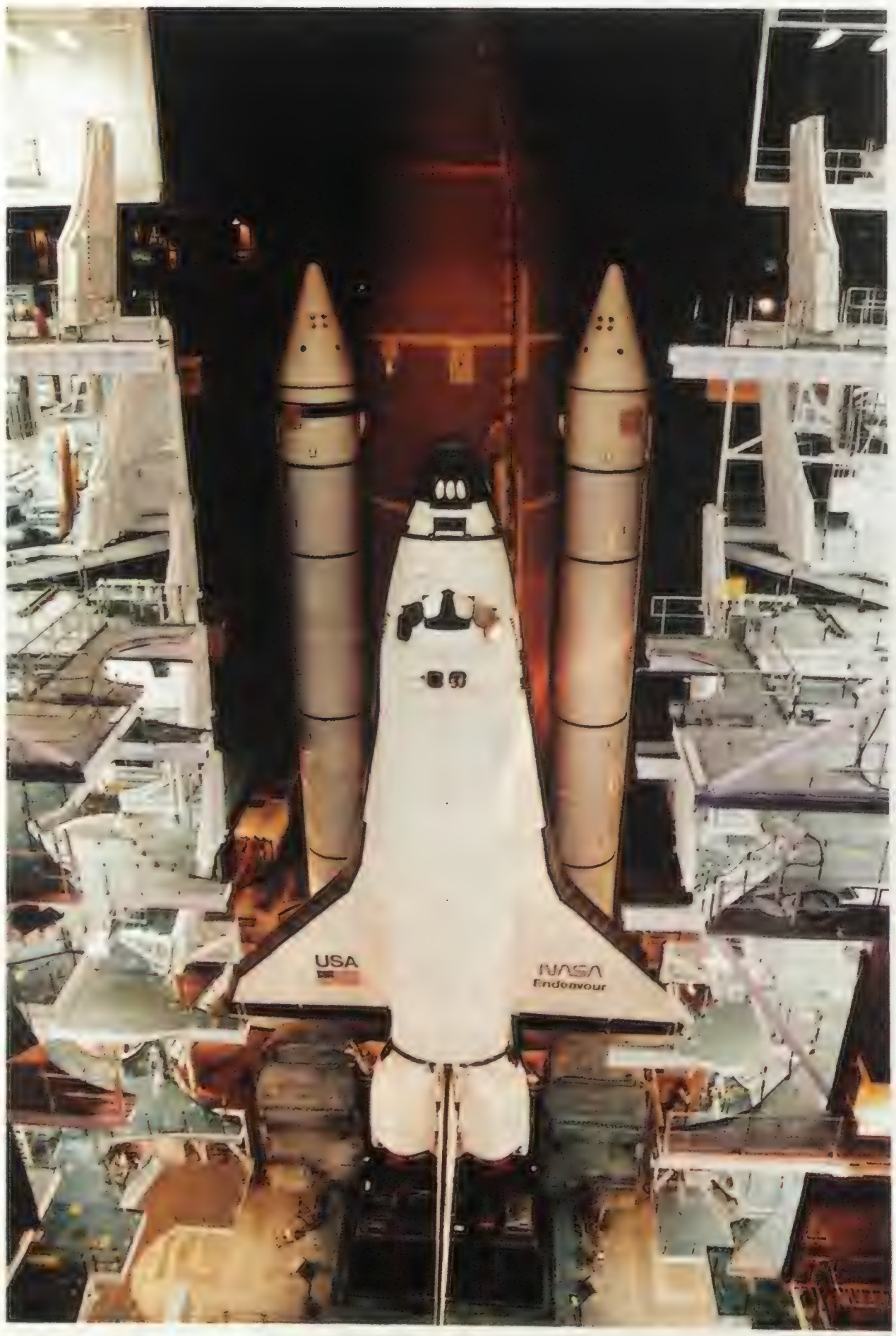
He admits, however, "that when the call comes, it's still a surprise." In the case of STS-68, the abort came at T minus 1.9 second, so close to launch that the official who announces liftoff said: "We have L...abort."

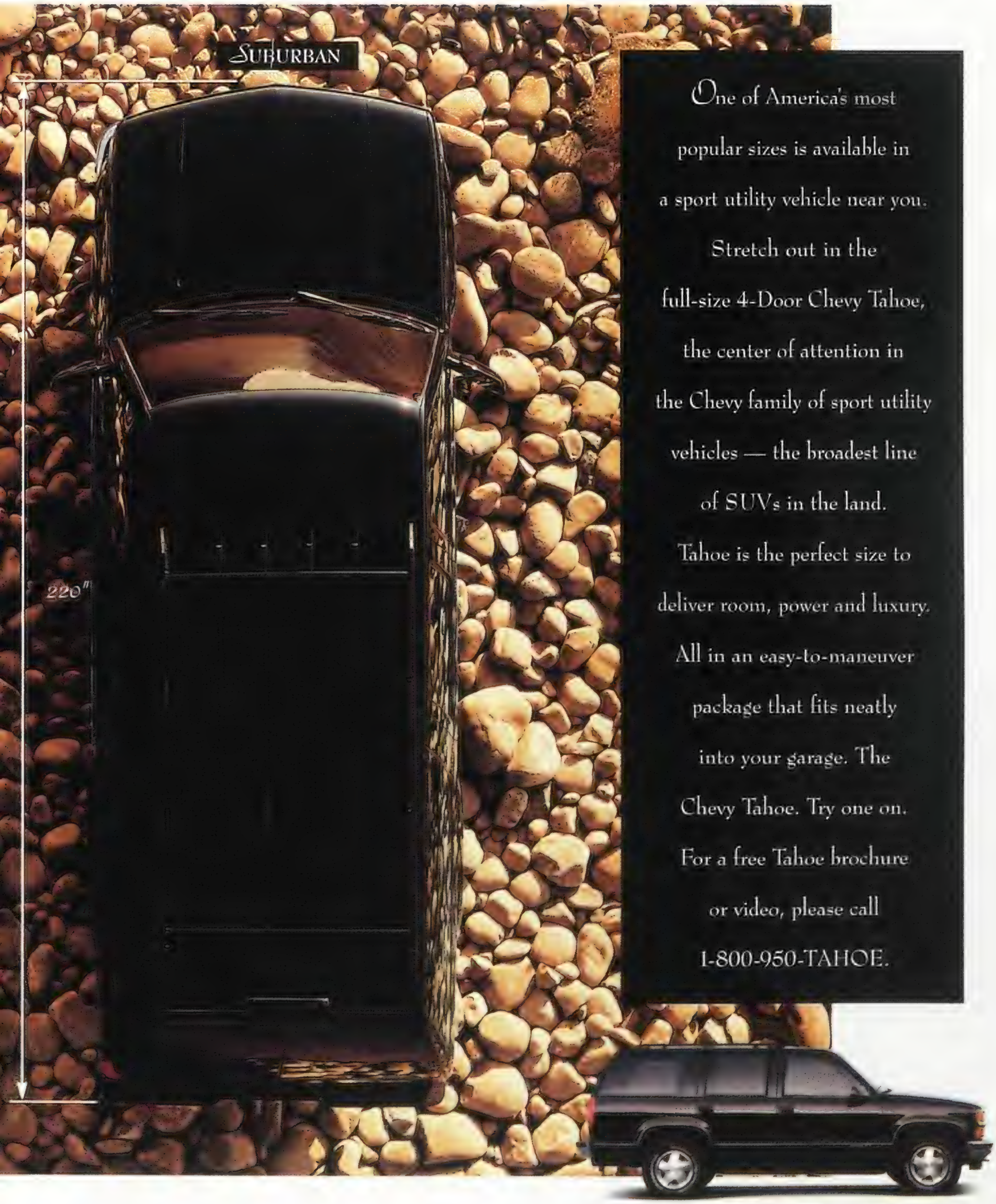
"It was the French abort," says Bartolini. "*L'abort.*"

He continues, "It was kind of shocking and then it's...you're all business."

It was especially shocking to Daniel Bursch, who was on this mission too. Because he has experienced main engine cutoff (MECO) four times yet flown only twice, his fellow astronauts have dubbed him the MECO Kid. "I'm fully ready for another pad abort," says Bursch, who is scheduled to fly on *Endeavour* next April. "I said it couldn't happen twice, and it did. Well, it could happen three times."

If it does, the launch team will bring the shuttle back to the vehicle assembly building and spend three weeks changing the engines. Once the engines fire, even for a few seconds, they're removed and serviced. Then the team will send the only reusable launch vehicle operating in the world back to the pad for another try.





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Wings

by Craig Mellow

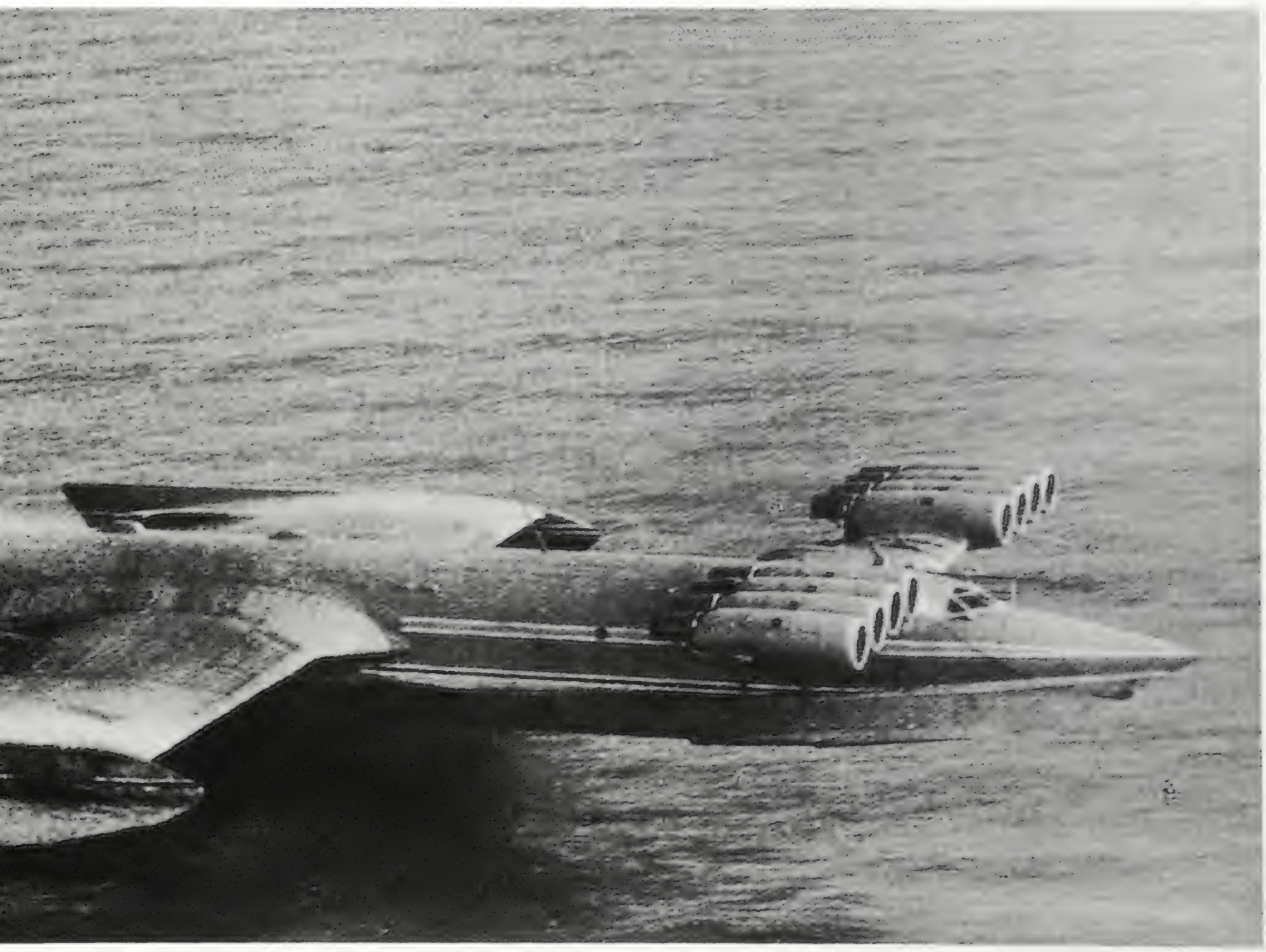
Photographs: ITAR-TASS/SOVFOTO

The heirs of Alekseev are keeping the flame alive in Nizhny Novgorod. It's been 30 years, yet they can still recall the thrill of seeing the master skid up to the testing center at nightfall on the big lake at Chkalovsk, driving 80 mph as he always did, his trunk full of the day's papier-mâché models. Then the disciples would shoot them off the catapults all night to see if they'd skim, wobble, or crash.

At eight the next morning Rostislav Yevgenievich would be back demanding results. To this day, people in Russian aviation above a certain age don't need to hear the surname Alekseev. You say Rostislav Yevgenievich—full name and patronymic denoting maximum respect—and they know whom you mean. Instinctively, they offer a moment of silence.

From those thousands of models came a flying machine like no one has ever seen before or since: a gigantically audacious cross between ship and airplane, with fat stubs of wings that couldn't lift it 50 feet, a tail five stories high, and eight ungainly engines behind the cockpit. It is a colossus only the Soviet military could have loved, much less financed. U.S. intelligence officers who spotted the object in surveillance photos nicknamed it the Caspian Sea Monster. Much later this name got back to Russia and stuck.

Yet Alekseev's monster flew. It lifted 540 tons, or 150 tons more than a Boeing 747 can, and three years earlier. It cruised at 310 mph—half a jet's speed. But it also floated, landing and taking off from the sea, and held a steady altitude 10 feet above the surface.



The "Caspian Sea Monster" (model KM) weighed over a million pounds and hit speeds of at least 310 mph.

Roughly the size of a Boeing 727, the amphibious Orlyonok could fly right up onto a beach (below). NATO code-named it "Orlan."

Thirty years later, the question is: Why? Why build it? And having built it, why abandon it? The Soviet Union carried out all sorts of technically dazzling projects that were useless at best—turning around rivers, running railroads thousands of miles across the taiga. For many years the Soviet military itself seemed inclined to lump Alekseev's work in with others in this category. And a recent report from the Pentagon's Advanced Research Projects Agency (ARPA) concluded that these giant craft offered no immediate boon to America's arsenal either.

Yet the heirs of Alekseev—grouped around a surplus conference table in a design space they have sublet from a bankrupt factory—continue to preach the faith all the same. Devotees of Monster technology are quietly at work in Germany and Japan. In Nizhny Novgorod itself—a graceful ancient city on the high banks of the Volga River—a modest pile of East Asian money is backing heir-in-chief Dimitri Sinitsyn as he struggles to show the world what to him is as plain as morning: "This is the transport of the 21st century," he says.

From the early days of flight, aviators noticed that as they neared the ground on landing, the ground had a tendency to push back. The airplane's passage appeared to create a pillow of compressed air that buoyed the craft even as it descended. The phenomenon, dubbed "ground effect," was studied as a complicating factor in takeoff and landing. It took a shipbuilder to see this pillow as something more than an aerodynamic nuisance.

Born in 1916, Rostislav Alekseev became the Soviet Union's preeminent designer of hydrofoils, the Russian for which translates as "ships on underwater wings." By 1954 his inventions had won him a Stalin Prize, the Soviets' domestic version of the Nobel, and his own design bureau outside of Nizhny Novgorod (then called Gorky). The Central Hydrofoil Design Bureau (CHDB) remains one of Russia's most reliable industrial hard currency earners, with 70 of its boats working as ferries in the Mediterranean alone.

By 1960 Alekseev had pushed hydrofoils to their speed limit of about 60 mph, but he wanted to go faster. "You might say the driving force in his life was a desire for speed and risk in general," recalls Vladimir Pleshivtzev, a former Alekseev lieutenant. "You saw it in the way he drove, in his fanaticism about downhill skiing. He became an excellent pilot too, and insisted on testing all the designs himself."

The Bartini Approach

Three views of a Bartini-style wingship (below) reveal the key differences between his design and those of the Alekseev school. Instead of stubby wings with tip floats, Bartini wingships have twin hulls that form an air channel. Perhaps more important, they also have an airplane-like wing mounted outboard, enabling the craft to climb above ground effect.

Phases of WIG Flight

Wing-in-Ground-Effect, or WIG, craft use engine thrust combined with a special wing design to provide very efficient flight close to the water's surface. Conventional aircraft experience changes in ground effect too, but only on takeoff and landing. According to M. Leroy Spearman, who has studied WIG flight at NASA's Langley Research Center in Virginia, wingship flight involves four transitional stages marked by changes in engine thrust vectoring and wing flap angle:

(1) Powered Ground Effect

On the surface at zero velocity, engine exhaust flow is directed under the wing, creating an air cushion contained beneath the wing by tip floats, which act as endplates, and wing flap deflection. High pressure builds up under the wing and lifts the vehicle out of the water.

(2) Augmented Ram Wing

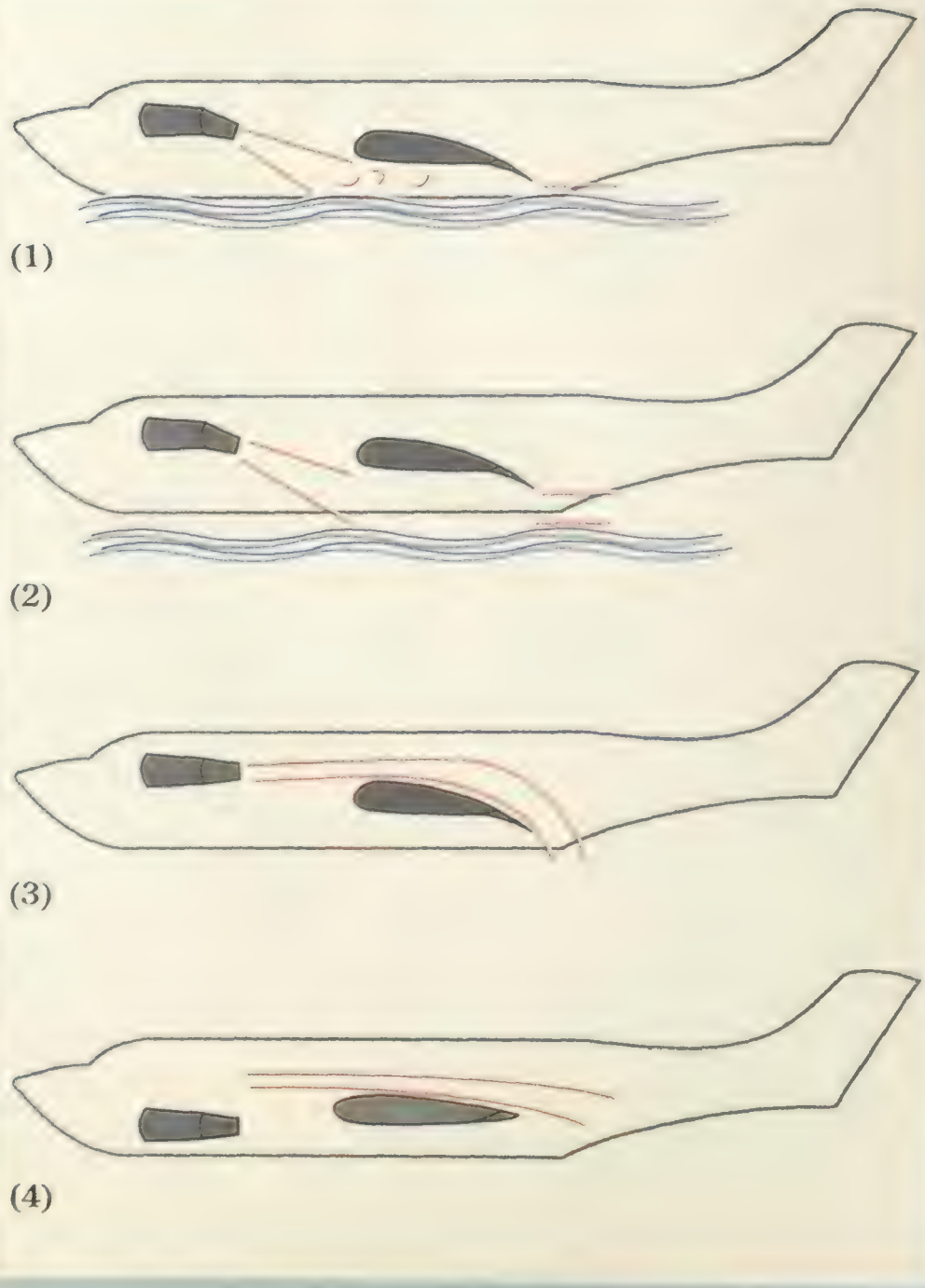
Using the ram effect of the air cushion and the acceleration from the forward engines, the vehicle begins to move forward and up in ground effect. Flaps are still down to entrap more air.

(3) Low-Speed Performance

Moving out of ground effect, the craft gets high lift at low forward speeds by directing the engine exhaust flow over the wing with flaps deployed. The flow tends to follow the curve of the airfoil due to the Coanda Effect, a phenomenon in which moving fluids tend to adhere to curved surfaces.

(4) Cruise Performance

Out of ground effect at cruise speed and altitude, the craft gets lift at low angles of attack with thrust augmentation provided by directing the engine exhaust flow over the wing with flaps retracted.



The Lun began as a missile-launcher but has recently been redesigned for rescue missions under the name Spasatel.

To Alekseev, the way to go faster seemed plain enough: Get the ship out of the water. However, his flying ship would remain aloft by a principle rather different from that which lifts airplanes. Instead of striving for lightness, it would make use of its enormous mass to create an air cushion as firm as a great set of bedsprings. He would call his invention a surface plane, or ekranoplan.

Alekseev transformed his theory into reality in a remarkably short time. The ekranoplan program luckily coincided with the "Khrushchev thaw," during which Soviet Russia momentarily allowed the energy of youth and freedom a day in the sun. Nikita Khrushchev, a lover of risk if there ever was one, spotted a kindred spirit in Alekseev, and he personally gave CHDB's funding requests a green light. The Caspian Sea Monster was flying by 1966, two years after Khrushchev was deposed by Leonid Brezhnev.

Of the many technical dilemmas faced by the ekranoplan's designers, the most important is simply stated by Igor Vasilievsky, CHDB's current boss. "It's the wing," he noted during an interview in the design bureau's small museum (the bureau itself is still subject to state security). "If the wing is too fat, it won't fly. If it's too thin, it will break when you land."

The wing is also the part that produces the air pillow, so the more surface area the wing has, the better. The result is a set of stubby wings with a long chord (the distance from leading edge to trailing edge). They look wobbly but fly stably under conditions that would challenge an airplane.

Hard-core ekranoplan adherents claim the hybrid has another inborn, almost magical advantage over the airplane. The more massive an ekranoplan gets, they posit, the better it can hold itself aloft on its own air pillow, and the less (relatively) it has to rely on its engines. Stephan Hooker, who was converted to the ekranoplan while studying it for the U.S. Defense Intelligence Agency, asserts that at 5,000 tons (about half the weight of a navy cruiser), an ekranoplan could fly with a lift-to-drag ratio (a measure of aerodynamic efficiency) of 30. The best airplanes today get 17 to 20.

To say the least, this theory remains unproven. The Soviets in fact steadily retreated from the Caspian Sea Monster's enormity as they cast about for some affordable application of Alekseev's breakthrough. The Monster's successor was dubbed "Lun," the Ring-Tailed Dove, a white bird that in Russian folklore symbolizes nature's purity. With lift capacity in the still-enormous 400-ton range, it was meant to be a flying destroyer, complete with heavy cannon and missiles.

Aircraft designer Burt Rutan visited Russia as part of a 1993 Advanced Research Projects Agency team.

After Lun came the much-reduced "Orlyonok," or Little Eagle. Maxing out at 140 tons, it was slated to be a troop transport and given an amphibious capability to crawl up onto a beach. With the veil of secrecy now largely lifted, it is clear that these machines had serious drawbacks. Their stability depended on an oversize tail, which, aside from its height, sported horizontal stabilizers with a span nearly as wide as the wings. Even with this heavy appendage, "stable" is a relative term. U.S. Air Force Colonel Mike Francis visited Russia as leader of an ARPA study group formed in 1993 and saw the sole surviving Orlyonok fly. He says the craft's tolerance for weight shifts forward and aft—its center-of-gravity range—is "terrible."

The ekranoplan also paid a price for its builders' knowing more about water than about air. "You kick the side of the thing and it's quarter-inch-thick ship aluminum," Francis observes. "Their view of structures and materials is still on a ship builder paradigm." Americans prefer to see more of the vehicles' weight as payload rather than structure.

The ekranoplan's mass did carry itself fairly well once it was airborne. CHDB's Vasilievsky claims the Lun achieved a lift-to-drag ratio of 17. But it needed enormous power to lift off. The eight forward engines on the Lun and the Monster had only one purpose: to blow enough air under the wings for takeoff. For cruising, two rear engines were sufficient.

But most damaging by far to the ekranoplan's development were Alekseev's mounting political problems. "I guess you could say he was an egotist in our collectivist society," ruefully recalls his daughter, Tatyana, an engineer who still works in CHDB's recently revived ekranoplan di-

vision. Alekseev had little patience with the hierarchy of Soviet science, which demanded that innovation flow from academic research institutes to design bureaus like CHDB and finally down to the factory floor. Still less could he be bothered with the bureaucratic pecking order. According to Tatyana's perhaps rosy account, her father also felt uncomfortable designing weapons, which put him at cross purposes with the ekranoplan's military paymasters.

In short, few men could be less suited to thrive under Brezhnev. In 1968, a mere two years after the Caspian Sea Monster's first flight, Alekseev was stripped of his CHDB directorship. The pretext may have been a crash that occurred during testing. Although the expensive machine was damaged beyond repair, the accident did demonstrate the ekranoplan's safety advantage over land-based airplanes: the crew was able to float peacefully until rescued. "It's very sad to say," recalls Aleksei Latyshenko, who left CHDB a few years ago to form the private design firm Trans-Al (the "Al" is from Alekseev), "but when the minister came and put all Alekseev's deputies around the table, they all said something bad about him."

Alekseev did remain in charge of a dwindling ekranoplan program until 1975. After that he became an ordinary employee. His daughter was forbidden to assist him, due to an obscure regulation against relatives working together. Yet Tatyana considers her father's last five years perhaps his most productive. He did indeed turn to peaceful ekranoplani, sketching a series of river-going vessels for anywhere from six to 250 passengers. Then he turned his attention to the "flying wing," a stealth-bomber-style ekranoplan that would be unhindered by a fuselage. With age, he increased his nightly sleep from four hours to five.

Rostislav Alekseev died in 1980 from a hemorrhage that occurred while he was dragging a new model onto a frozen lake for testing. He died penniless, in a three-room apartment inherited from his in-laws, which at times housed 11 people. Tatyana Alekseeva lives there now with her two sons, who play in a rock band called the Jolly Cannibals while they attend the shipbuilding institute.

The SM-8 preceded the giant KM and featured a shield to prevent water spray from entering the rear engines.

A second front in the fight to develop the ekranoplan opened in the early 1970s under the aegis of a still more extravagant personality, Robert L. Bartini. Russia being a place where Communist materialism never quite drove out peasant superstition, many who knew Bartini quite seriously suspected he had come from outer space. The more credible story is that he was born a minor count in turn-of-the-century Northern Italy. He studied physics and Communism simultaneously in post-Hapsburg Vienna, and in the early 1920s foiled a plot by Italian Fascists to assassinate Lenin.

After a bit more derring-do in Berlin, Bartini moved to the Soviet Union and quickly made his mark as an aircraft designer, setting speed records and achieving breakthroughs in bomber design. In 1938 he was caught up in Stalin's mad purges of the military and spent the next 10 years in labor camps. While still a prisoner, he was brought to Taganrog, on the Sea of Azov, to head a new design bureau staffed exclusively by fellow inmates. Finally freed after Khrushchev secured power in 1954, he stayed on to work on seaplanes at the Beriev Design Bureau, which specialized in large, water-based airplanes.

As Alekseev was the inveterate engineer, so Bartini was the born theoretician (though he never lost his Mediterranean impulsiveness, once diving from a battleship's mast to impress a woman). His craft having descended from the sky rather than risen from the sea, Bartini called his ground-effect vehicle ekranolet, from the Russian verb *letat*, to fly. Its central innovation was a wide, flat body in place of Alekseev's conventional tubular one. The body itself contributed to the surface effect, so in theory, the ekranolet could cruise at a much higher altitude relative to its mass.

"With a 35-ton plane, the VVA-14, we could feel the surface effect very strongly at eight to ten meters," explains Leonid Fortinov, a key Bartini assistant who is still deputy director at Beriev. "This means a plane the size of the Caspian Monster could fly at 50 to 100 meters, high enough to go over ships and most bridges."

Insufficient altitude was indeed the Alekseev ekranoplan's most obvious flaw. The Monster cruised at no more than 10 to 12 feet, not high enough to risk oceanic travel. The Orlyonok, with its smaller mass producing a smaller air pillow, could barely make six feet.

Bartini, as the Russians like to say, "worked out" the plans for ekranoleti of up to 2,500 tons gross weight. "Of course we could have built them," Forti-

nov loyally asserts. But life got in the way. Having sketched the physics of a revolutionary form of transport, Bartini was happy to let future generations fill in the details. Production of engines for a second generation was farmed out to an incompetent contractor. And the master himself, in the last years of his eventful life, had other things on his mind. The obsessions of his waning days were a theory of a six-dimensional universe that would facilitate time travel, and, a bit more modestly, the establishment of a world academy of transport. When he died in 1974, he left orders for his papers to be sealed for 300 years.

While Alekseev and Bartini respected each other personally, their bureaucratic masters ensured that their organizations achieved no synthesis. "We never heard of Bartini's work until 1975," says Igor Vasilievsky in Nizhny Novgorod. By then Bartini was dead and Alekseev had gotten his final demotion. It was too late.

The ekranoplan faithful spent the 1980s "sort of working underground," as Dimitri Sinitsyn puts it. A modest revival of the art began in 1988, when the Soviet nuclear submarine *Komsomolets* sank in the North Sea with all its crew. Government officials in Moscow speculated that an ekranoplan might have saved the sailors, and CHDB was commissioned to build a new Lun outfitted for ocean rescue. As described by Igor Vasilievsky, the new model will be a flying hospital ship, with room for 500 passengers. The rescue Lun will also be able to ascend to almost 10,000 feet, deemed the maximum altitude practical without a pressurized cabin. So an ekranoplan stationed in the Baltic could cover the Barents Sea too, easily traversing the slice of Finland that separates the two.

The Soviet Union's bankruptcy and disintegration have slowed CHDB's work to a snail's pace; Vasilievsky makes vague promises of a test flight sometime in 1995. But the new order also allowed scientific talent to break free from the Central Design Bureau monolith and search for support beyond Russia's borders.

The main CHDB "defector" firms are Sinitsyn's Technology and Transport (T&T) and Latyshenko's Trans-Al. While both men were close to Alekseev, Latyshenko has for the moment turned his back on the ekranoplan: "An ekranoplan has to be very big to realize its effectiveness," he says. "Whether to commit the resources is for politicians to decide. There is no commercial application yet."

To the T&T crowd, this kind of talk borders on treason. "Of the 100 people who work with Sinitsyn, at least half are fanatics," notes Kirill Rozhdestvensky, a physicist at St. Petersburg's Marine Technical University who was himself bitten by the ekranoplan bug while providing scientific backup for Alekseev. "I guess this was Rostislav Yevgenievich's greatest achievement—that he infected a large number of people with his ideas," Rozhdestvensky says.

T&T's "fanatical" position is that an ekranoplan can be produced profitably right now. The firm's strategy is to pick up where Alekseev left off, with small ekranoplanchiki (the Russian diminutive) for calm waters. They have found investors, Sinitsyn says, "in east Asia, where there is a lot of water."

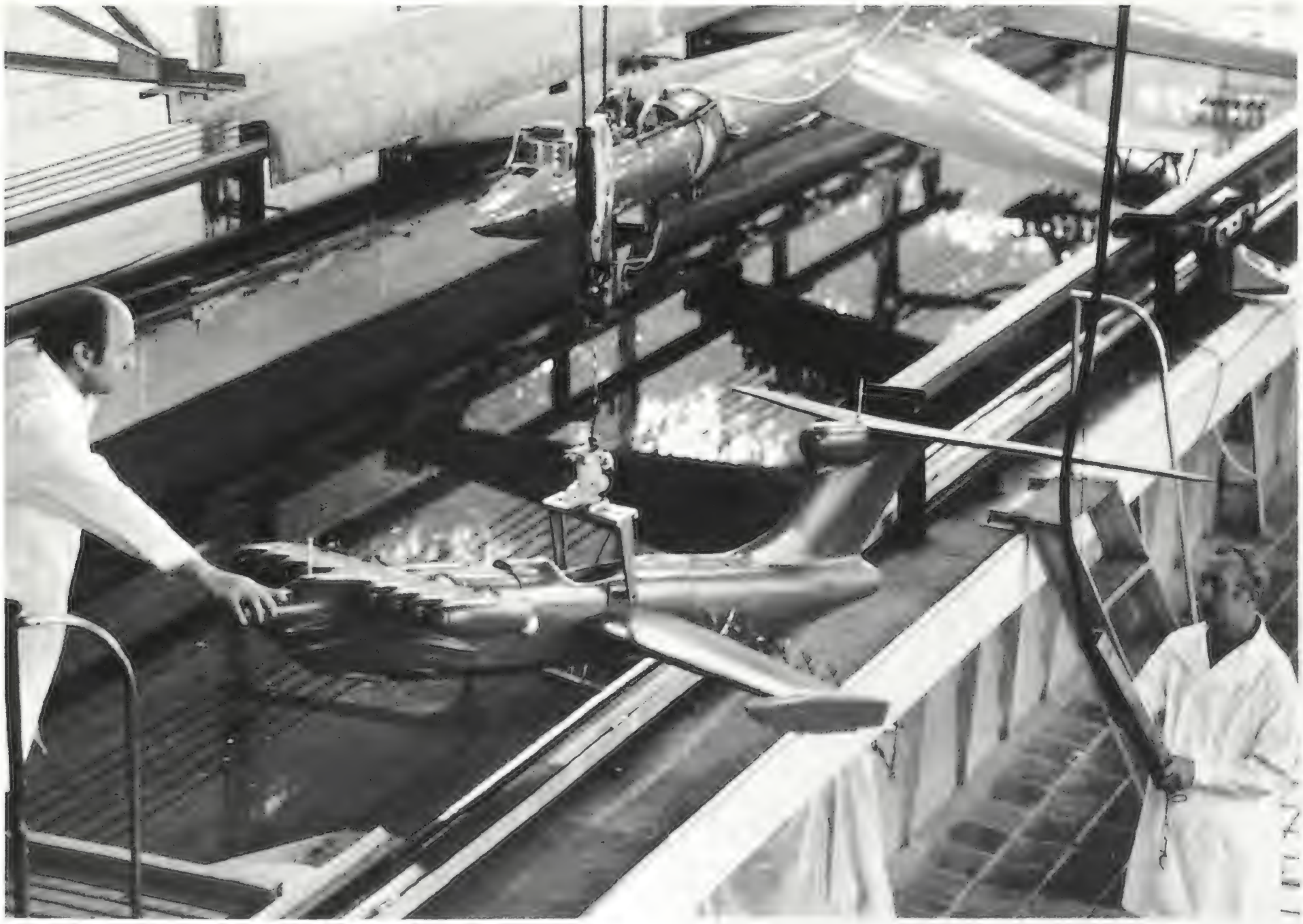
In a garage adjoining T&T's offices, artists are doing work Alekseev would have applauded, patiently planing plywood and Styrofoam for the full-size mockup of the firm's six-seat cutter, supposedly set for a test flight on the Volga in 1995. Upstairs, rows of technicians draw circuits on big wooden drawing boards: There is no computer in sight. "Americans use so many computer models they lose the physical sense of what they're building," says Sinitsyn, raising a point most Russian scientists can expound upon at passionate length.

The cutter entirely rejects the heritage of Soviet gigantism. Its power source is a souped-up Subaru automobile engine, and anybody who can handle a motorboat can drive it. When you're finished flying, you can pop the wings off and throw the body on top of a car. Cruising speed a couple of feet above the surface is about 100 mph. The cost is estimated at between $200,000 and $250,000.

Aside from appealing to island-hopping executives, Sinitsyn hopes to grow a market among police and customs authorities in archipelago countries, such as Indonesia. He claims the cutter uses one-fourth the fuel a helicopter needs and is much quieter.

If the cutter flies in the market, T&T is ready with an Orlyonok-size follow-up. Through 20 years of persistent effort, Sinitsyn says, he has managed to enlarge the ekranoplan's wings and shrink its tail, giving it two and a half times the fuel efficiency of Alekseev's models while doubling its range to more than 2,400 miles . "The Lun, which the government is trying to sell, is a morally tired, 20-year-old plane," says Sinitsyn, taking a healthy bite from the back of his old comrades at CHDB. Vasilievsky returns the favor, calling Sinitsyn and

The Russians have been scaling down to river-based craft like this Volga. Some Americans want to scale up to vehicles of 5,000 tons.



company "theoretical types," whose departure "made some room for the younger generation."

The most obvious use of a nouveau Orlyonok would be as a ferry carrying about 250 passengers. But like all true lovers, Sinitsyn is forever finding new dimensions in the beloved. One of his favorite stories is of a chance meeting in Washington (where he testified on the ekranoplan before Congress in 1993) with dignitaries from the Mariana Islands. "They told me they couldn't go home without an ekranoplan to fly fresh sushi to Japan," he recalls. "There's a use I hadn't thought of before."

Ironically enough, humongous ekranoplani have gotten their most careful study of late in the United States, thanks in large part to the dogged devotion of Stephan Hooker, who managed to wedge into the 1992 defense appropriations bill a feasibility study for his dream, a 5,000-ton "wingship." When Mike Francis took the U.S. investigators (among them airplane designer Burt Rutan) to Nizhny Novgorod, the Russians for once found their own imaginations outmatched.

"The materials exist to hold a 5,000-ton skeleton together," Igor Vasilievsky noted circumspectly. "But it's hard to imagine the engines you would need to power it." Dimitri Sinitsyn added, "A thousand tons is realistic. Five thousand tons is not so realistic."

Given these reactions at the fountainhead, it is not surprising that ARPA itself ended up lukewarm. "This technology is too early in its infancy to throw cold water on it," Francis concludes. "There is certainly value in the craft's ability to sit in the water when it needs to. But whether it can ever justify itself on a range-payload basis, I don't know."

In hungry Russia, meanwhile, the high-powered, big-talking American delegation raised hopes that turned to resentment—and worse. "Three years ago we were oriented toward the U.S.," Sinitsyn says. "But then nothing happened." Although Sinitsyn never met the ARPA delegation, he felt the brunt of a limited national security reaction that followed their visit. In the summer of 1994, T&T's offices were ransacked by Russia's Federal Counter-Intelligence Service, successor to the Soviet KGB, and Sinitsyn and others were threatened with prosecution. Fortunately, nothing has come of that either.

At the still-active design bureau Alekseev founded, technicians prepare a research model for a towing tank.

We are used to thinking of technology as an objective force, which, if truly useful, will chance upon a mind suited to develop it further. Building the ekranoplan is a bit different. High cost and tight secrecy made the technology of the wingship more like that of a pre-modern craft, something that must be lovingly passed down through generations of masters. Because of the blank years from 1975 to 1990, the younger generation is mostly absent. The heirs of Alekseev fear that if the world does not soon decide to save the ekranoplan, the idea will be lost and the flame doused. If that happens, Dimitri Sinitsyn concludes with classic Russian grandeur, "We will not have performed our duty to mankind."

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ADVERTISING SPACE

In late 1992, NASA held a series of six "town meetings" around the country in which agency administrator Dan Goldin fielded questions and comments from local citizens. Among them:
"The average citizen is not aware of how NASA technology affects their lives. If they did, they would probably be more supportive of the program."
"The public has no clue what the purpose of the Space Station is. Please educate us so we can support it."
"A lot of Americans feel a great separation between themselves and the space program."

NASA's in trouble. The reasons can be debated, but the fact is, the agency has lost its ability to enchant the American public. Some of the shuttle experiments of recent years have immeasurably deepened our understanding of astrophysical processes, and the observation craft have sent back some lovely, momentous images—planets, stars, quasars, evidence of black holes—but the public, it seems, remains either unaware or unimpressed.

If NASA were a corporation, the solution would be clear. Madison Avenue is packed with advertising agencies ready to spread the word about their clients' good works. Of course a government entity can't avail itself of such services...but what if it could?

We decided to ask a group of top advertising houses from around the country how they would go about reawakening America's appreciation of its space agency. Five volunteered their time and talent to produce the hypothetical campaigns that follow.

Hey, everyone else is doing it. NASA

Agency:
Kresser Stein Robaire, Santa Monica, California
Copywriter:
David Locascio
Art director:
Mark Cohen
Creative directors:
John Stein and Jean Robaire

Photographs:
Bettmann Archive

Major clients include:
ARCO, Kaiser Permanente, Packard Bell, United Paramount Network, Wolfgang Puck Food Co.

We approached this project the same way we approach any ad. We think each ad should try to communicate only one simple idea. So we sat down and tried to figure out what that one idea should be.

How could we justify the United States government spending billions of dollars on something that Americans know so little about? Let's face it, most people don't really care that it takes 27.3 days for the moon to complete a full revolution around Earth. They don't care that the surface of Venus is hot enough to melt lead. But people do care about the mystery of space, the possibility that there's life out there somewhere. Excluding the space programs of other nations, NASA is the only link we have between the known and the unknown.

There have been thousands of UFO sightings over the years. It is not logical to say that UFOs don't exist. We thought that the only way we could justify the space program was to communicate to people that NASA shares our desire to find out what's out there. That's a benefit people can relate to.

As for the look of the ad, we thought it should be simple. We wanted the ad to convey a feeling of mystery and intrigue. We think the simple headline, the dominating black space, and the simplicity of the layout help convey the feeling that we were looking for and, as we finally concluded, the feeling that a program like NASA warrants.

When you get an assignment like this, the first thing to do is sit down and get all of the clever, hip, ad-style ideas out of your system so you can get on to something meaningful. Early thoughts ran from the whimsical (astronauts wanting to golf other moons) to the fiscal ("The Voyager mission—just pennies per mile!").

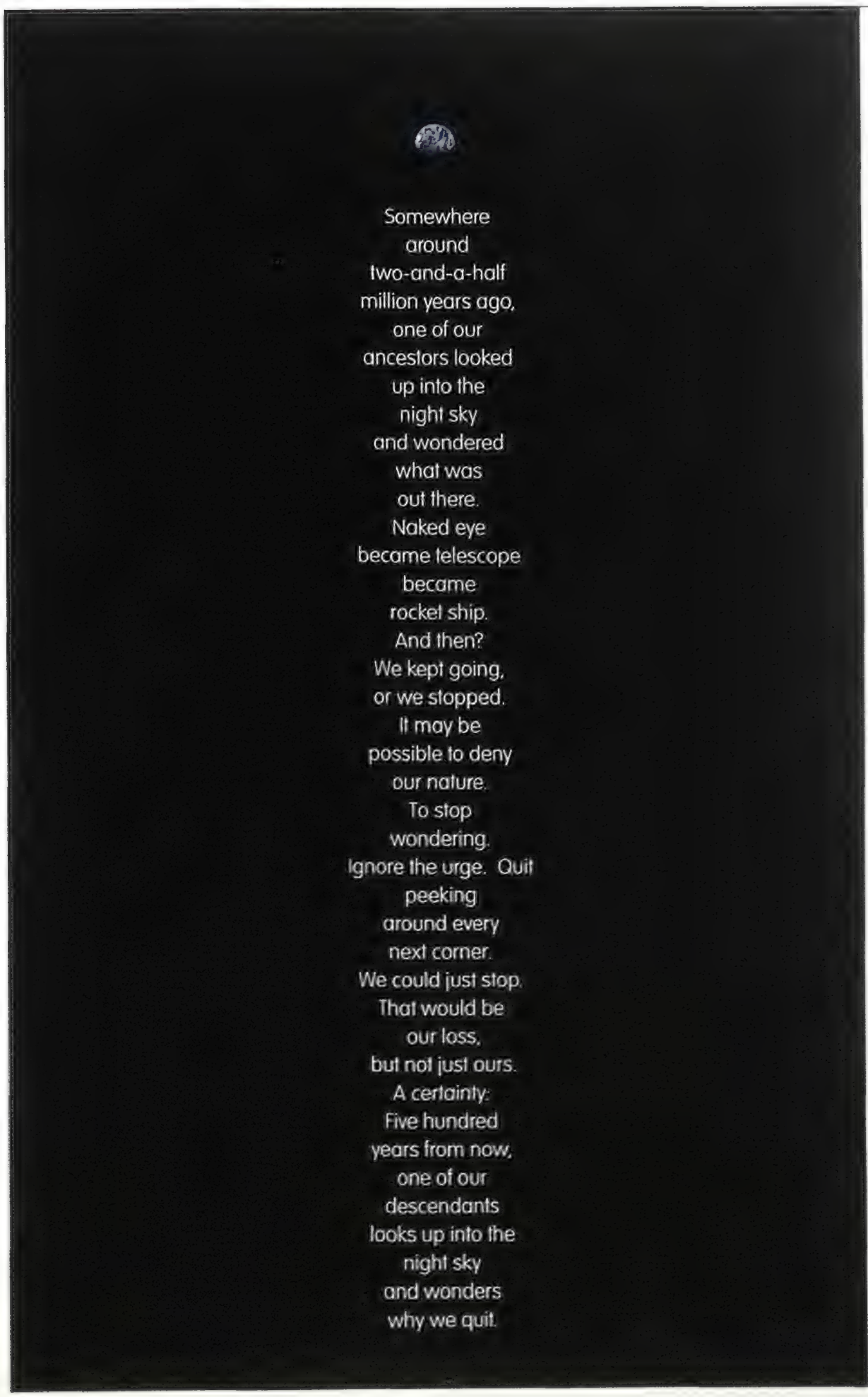
We moved on. One day as we were staring at each other, trying to figure this thing out, Carolyn McGeorge did the layout you see here. Ah, Carl Sagan's "pale blue dot." We sat there looking at that lonely little orb in black space, wondering what it meant.

After a while, we imagined a hairy guy wearing animal skins, looking back at us. Also staring us in the face was a simple question: Who hasn't looked up in the night sky? Answer: Nobody. Ever.

So the argument for space exploration is this: We have to go. It's in us. Always has been, always will be.

The copy took off from there. All we had to do was write the truth.

(We invented the logo and the organization it represents. The array of lines is taken from the "Greetings from Earth" message aboard the Voyager 1 and 2 space probes.)



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Carolyn McGeorge
Writer:
Joe Nagy
Creative director:
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Photograph:
NASA

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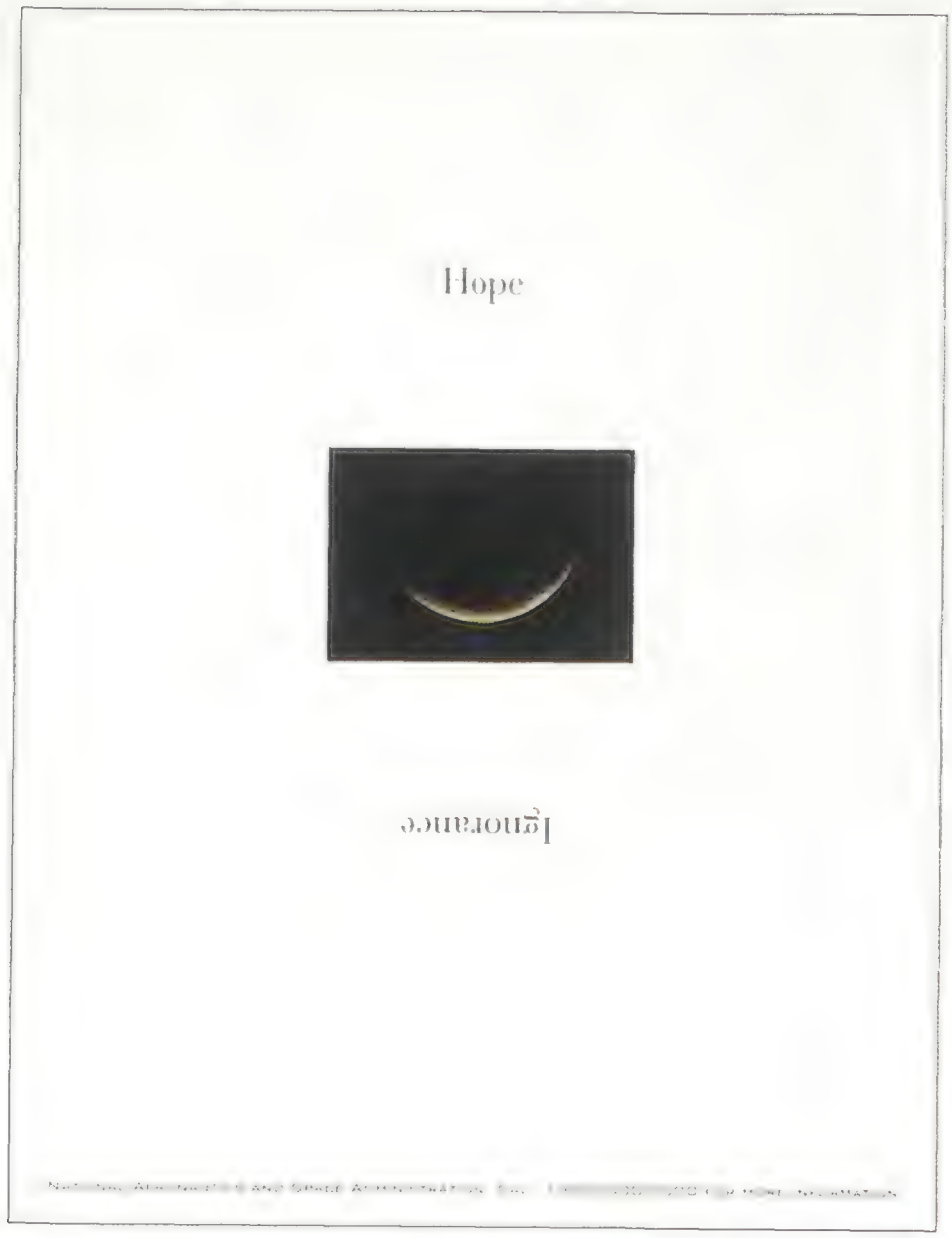

First we had to crystallize our own opinions about NASA. Mismanaged space agency whose best days were behind it, or restructured agency that just gave us our first glimpses of creation with the extraordinary Hubble telescope? We opted for the latter, deciding that the passion for new frontiers was too ingrained in the human psyche for us to just throw up our hands and give up. Congress is currently deliberating slashing NASA's budget. How to convince a skeptical public that space is too important to disappear? Our creatives tried several approaches. One, "Hope/Ignorance," sends a simple message brimming with power. Another uses the crop circle phenomenon to remind us that if extraterrestrial life is out there, NASA is our best hope of finding it. And the third uses humor to warn us that if NASA vanishes, plenty of other nations are waiting to fill the void. Bottom line: We need NASA. The human mind just wasn't born to stand still.

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Jerry Olson
Susan Lieber
Robert Perillo
Judi Sohn
Dick Ellington

Photographs:
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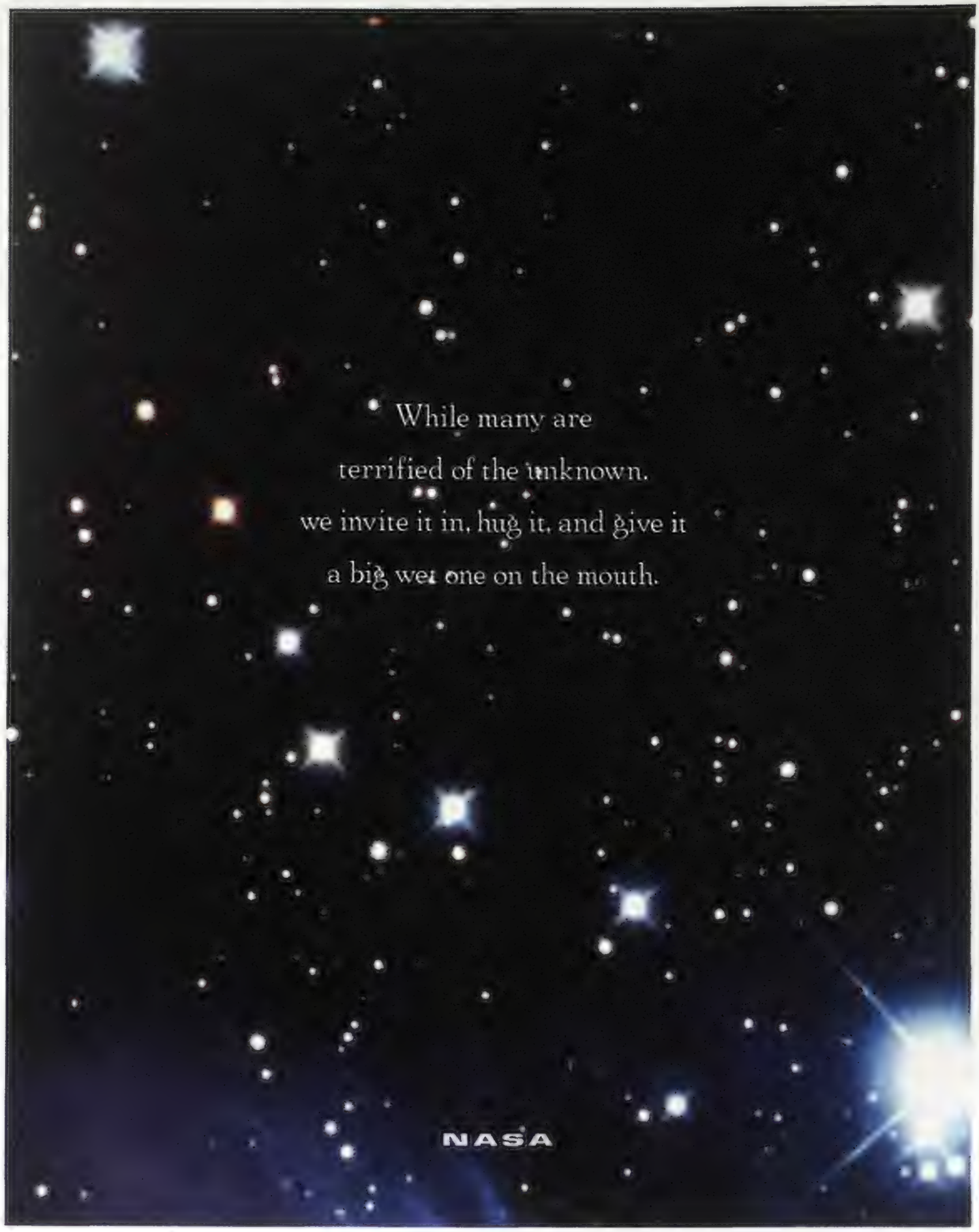

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Copywriter:
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Photograph:
"The Pleiades,"
Bill and Sally Fletcher

Major clients include:
Anheuser Busch, Harley-Davidson Motor Company, Korbel Champagne, Norwest Bank, Rollerblade, Schwinn

NASA is no longer thought of as the icon of Americana. It has come to be known as just another government organization draining our federal tax dollars. The challenge for us was to rekindle the relationship between NASA and the American public. By renewing the mystique of space exploration and expressing NASA's passion for the unknown, we can help Americans begin to understand the value of today's NASA and become emotionally reconnected to the organization. Our creative execution communicates NASA's position as America's space program—a valuable and trusted organization that will bravely lead us into the future. But the ad communicates the position through the passionate and conversational attitude that reflects NASA as a strong, futuristic organization with boundless human spirit.

The ad serves as a wake-up call to the American people to embrace NASA as NASA is embracing the unknown, thus awakening our national passion and discovering the importance of space exploration once again.

An ad is meant to persuade you to do something. Usually, that something is to buy a product or a service. But sometimes they're asking you to buy an idea.

What may be bad news to some marketing professionals is that consumers are not mindless cattle who rush out to buy the latest whatever-it-is simply because they're told to. If you want to communicate something, you need to engage your audience in the message.

So we show you a photo you've probably seen a million times. "Oh, yes. The planet. Seen it before. Quite lovely, really." But we hope it's the thought, not the photo, that might, just might, grab you.

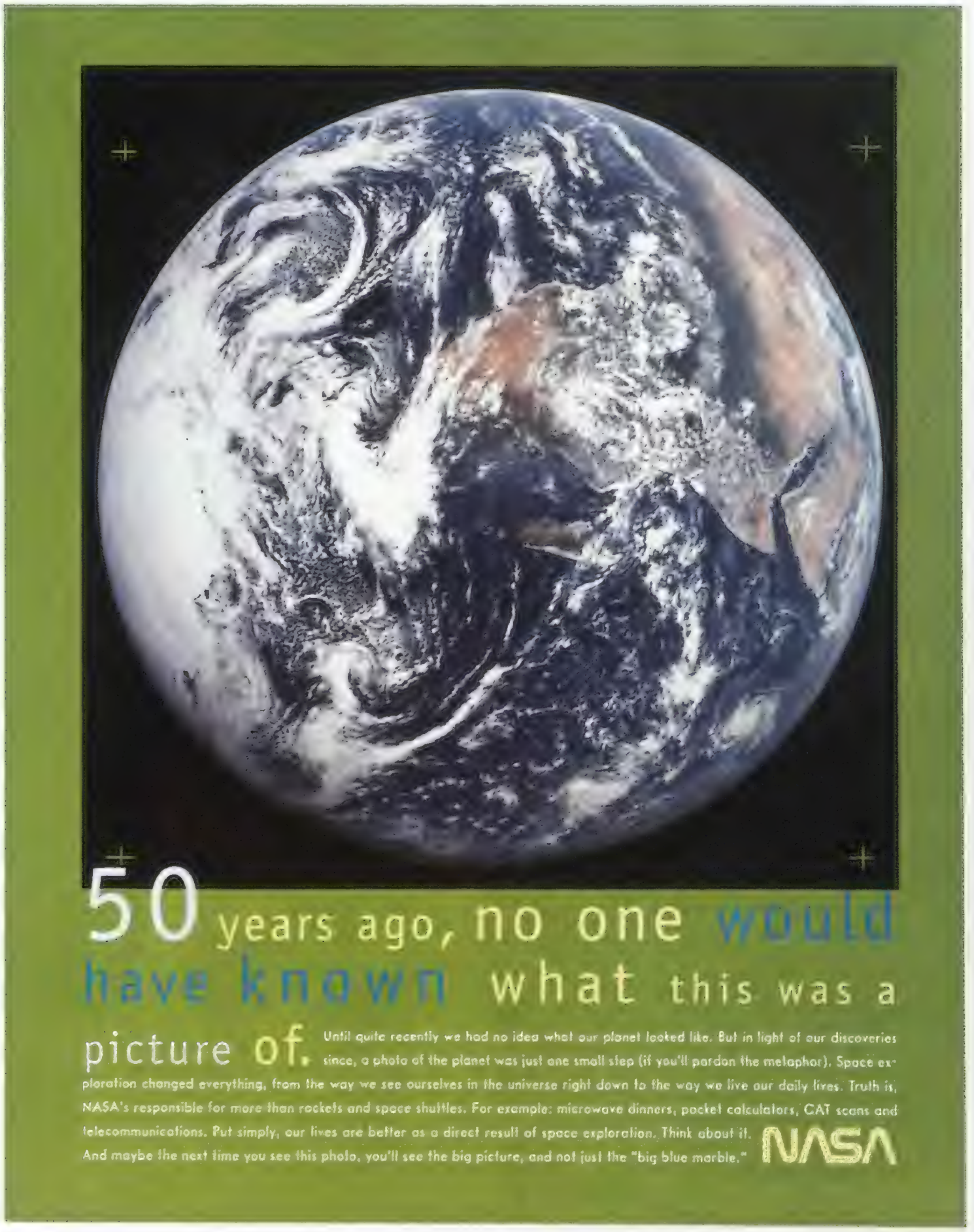
Here's the thought: NASA has had an incredible impact on daily life. That's why everybody *does* know what this is a picture of. In this context, the photo becomes a symbol of all NASA's contributions.

To summarize: The ad is simply a new way of looking at an old photograph.

Agency:
Citron Haligman Bedecarré, San Francisco
Creative directors:
Kirk Citron and Matt Haligman
Art director:
Roz Romney
Copywriter:
Barton Corley

Photograph:
NASA

Major clients include:
Foundation Health, Ore-Ida, Kenwood USA, KMS Shampoo, Copper Mountain ski resort



AUTO PILOTS

What has four wheels and flies? The dream of a roadable airplane continues.

by John Grossmann

The flight instructions went something like this: "It's easy. It practically flies itself. I'll tell you what to do as we go along."

In the summer of 1959, Moulton Taylor, with a little time on his hands and the zeal of a missionary, was seeking another convert. He'd given his student, a recent high school graduate named Ed Sweeney, the use of his Longview, Washington sod runway to fly radio-controlled model aircraft.

But this was no model. Nor was the four-wheel vehicle Sweeney steered down the runway strictly an airplane. Had Taylor stripped the craft of its wings and tail section, Sweeney could have signalled a couple of turns and driven into town, as Taylor sometimes did, on a head-turning jaunt to the grocery store.

With Taylor at his side, Sweeney left the ground at about 55 mph. "Okay, we're high enough," said Taylor. "Let's make a turn." Sweeney dialed the steering wheel and the Aerocar quickly responded. The landing was equally smooth. "Just drive it down the runway," said Taylor, "and when you're ready to stop, simply step on the brake." Sweeney enjoyed his brief drive in the sky, but his encounter with the Aerocar was not love at first flight. "It didn't mean all that much to me at the time,"

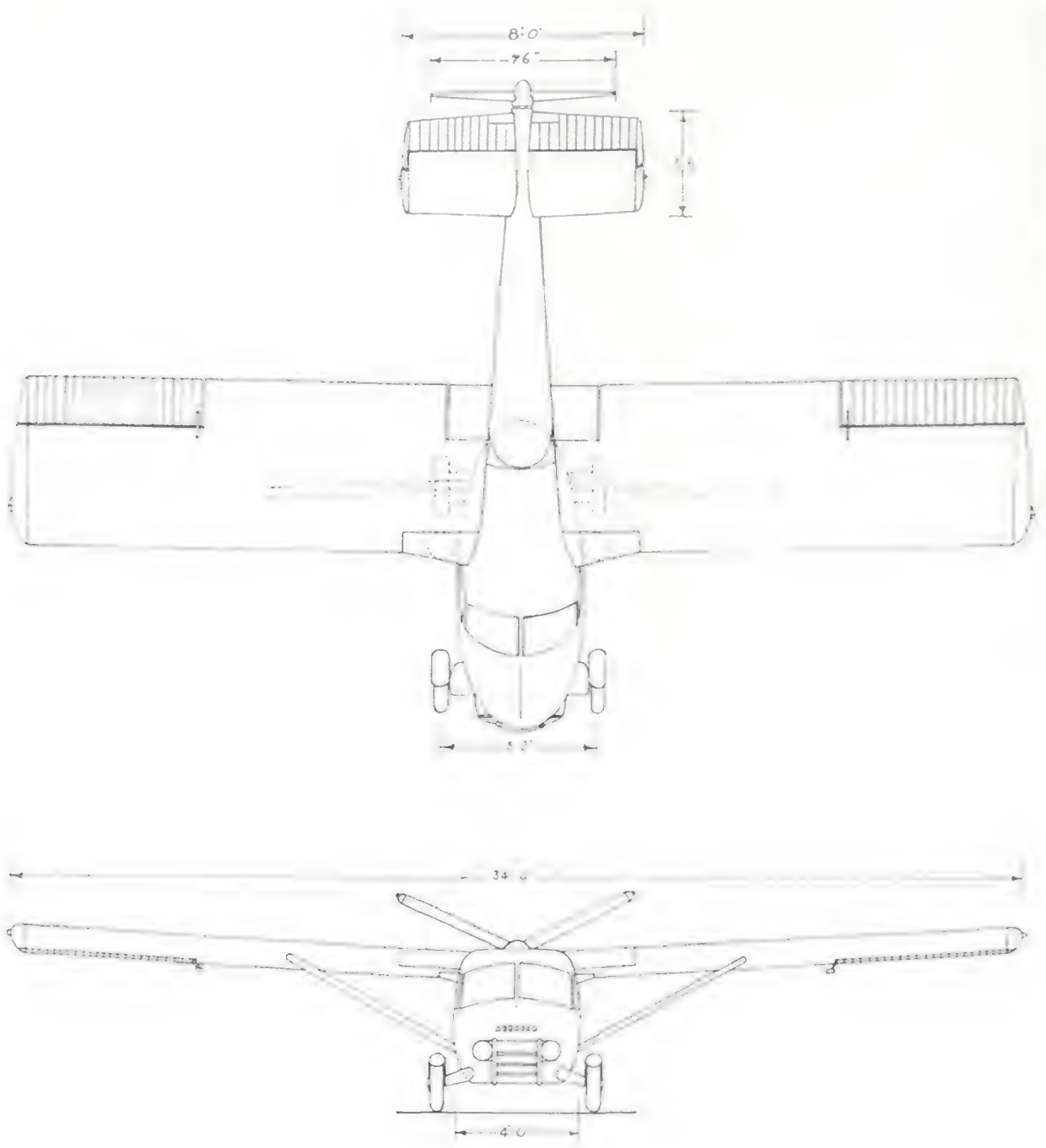
The media has always loved flying cars, particularly Molt Taylor's Aerocar. Taylor (inset), the dean of roadable airplanes, has devoted most of his adult years to making the Aerocar a reality. His latest version, the Aerocar IV, is based on a Geo Metro.

PHIL SCHOFIELD, SPREAD; COURTESY MOLT TAYLOR COLLECTION

he admits. It would later.

Aviation historians consign the flying automobile to the oddity hangar, a niche reserved for the Spruce Goose, the autogiro, and other noble though quirky experiments. But if a flying car has yet to attain success, the *idea* of one is still very much alive. Last December NASA's Langley Research Center in Virginia published a collection of papers on such topics as "The Advanced Personal Fixed-Wing Converticar," stating in an introduction that the advanced personal aircraft "may be right for the dawning of the new century."

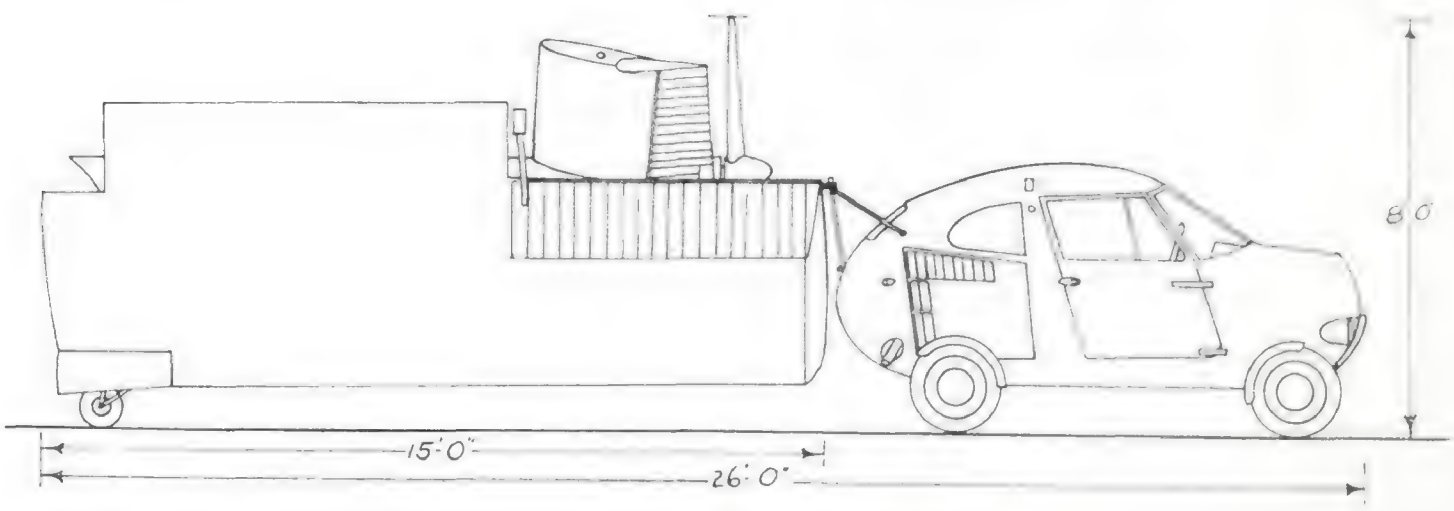
"I see a real resurgence of interest," says Palmer Stiles, whose book *From Wheels to Wings* provides a patent-by-patent history of the flying automobile, or "roadable" aircraft. Of 76 patents granted between 1918 and 1993, 10 bear dates of 1989 and later. And, as Stiles knows, you don't need a patent to sketch designs or build models or sweat over a breakthrough concept in a garage. Stiles' own design, pursued as an ongoing student project at the Florida Institute of Technology in Melbourne, where he is an assistant professor of mechanical engineering, proposes pivoting canard and main wings that overlap the car body for ground travel. Stiles calls it the CaRnard. Other enthusiasts, in the tradition of an earlier generation of roadable designs (see "To Build a Better Mousetrap," p. 73) like the Curtiss Autoplane, the Waterman Arrowbile, the Fulton Airphibian, and Molt Taylor's Aerocar, have staked their claim to an ever shrinking realm of hybrid names: Aircar, AviAuto, Sky Car, even Roadrunner.



COURTESY MOLT TAYLOR COLLECTION

All have turned up in the pages of *Roadable Aircraft*, a three-year-old publication mailed sporadically from the Edmonds, Washington home of design engineer Ron Borovec. Borovec serves as an information clearinghouse, cheerleader, and sounding board for those bitten by the flying car bug. "It's myself and a staff of zero," he says. Like Stiles, Borovec detects an updraft of interest in this long-dreamed-of advance in transportation—a variation of the helicopter in every garage. In the last year, subscriptions have climbed to 350, and attendance at his roadable aircraft forums at the annual Oshkosh, Wisconsin fly-in has grown apace.

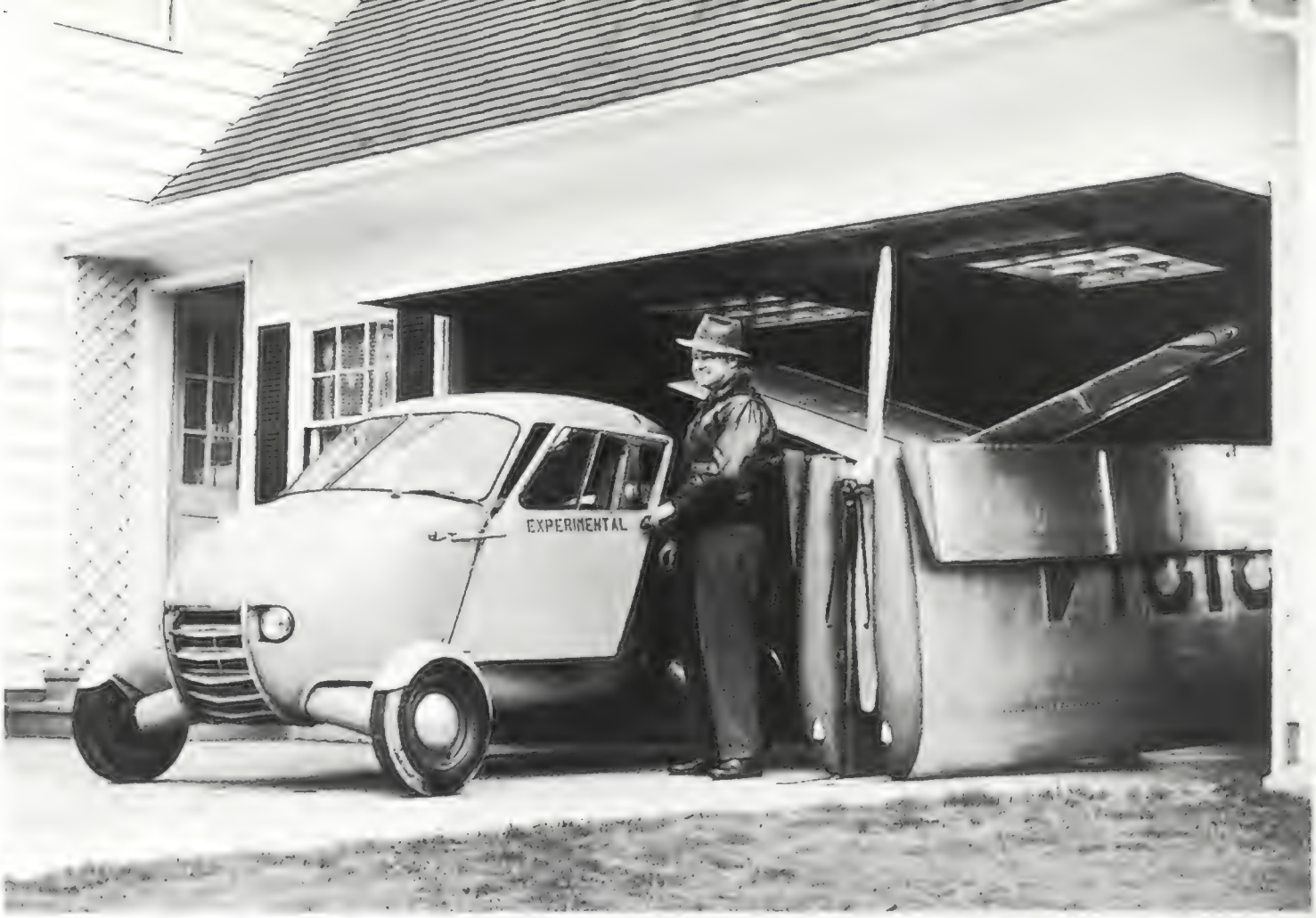
The need for such a dual-purpose vehicle looms greater than ever. Not only are roadways more congested with each passing year, but the airlines' hub-and-spoke system has, over many mid-length routes, actually increased travel times. But that's only part of what inspires flying car designers. As Chuck Berry sang in his 1956 recording "You Can't Catch



For maximum utility, Taylor's Aerocar could tow its flight components rather than leave them at an airport.

Me," the ability to transform a car into a plane is liberating—freedom at the push of a button:

I bought a brand new Aeromobile.
Custom made, 'twas a flight de ville.
With a powerful motor and some highway wings,
Turn off the button and you will hear her sing.
Now you can't catch me. Baby, you can't catch me.
'Cause if you get too close, you know I'm gone
Like a cooool breeze.



HOWARD LEVY

But the flying car remains a romantic vision, a kind of aeronautical mirage. The challenges of building one are perhaps exceeded only by the challenges of selling it. Because a vehicle worthy of both land and air has compromise written all over it, the technical challenges are numerous. The common elements are few: fuel tank, steering wheel, passenger and baggage compartments, wheels, and engine. For flight you need wings, ailerons, a horizontal stabilizer, a vertical tail, rudder, elevators, and a propeller, none of which has any business on a car. For the road, you need a drive train and bumpers, not to mention rear-view mirror and, nowadays, catalytic converters—all dead weight in the air. The history of flying cars can be written in a single sentence: As airplanes, they've all been too heavy.

Still the quest goes on. "A lot of people are just technically curious," says Borovec. His even-handed approach to presenting and encouraging the dreams of others prevents him from picking favorites or even handicapping any of the imaginative and divergent approaches, which range from simple kit-built vehicles to a James Bond-like concept with sleek lines and telescoping wings. (Even 007 himself hasn't seen a real flying car. The one in *The Man With the Golden Gun* was a static model "flown" by Hollywood special effects.) "There are some good designs out there" is all Borovec will say.

One of the most credible belongs to Molt Taylor, now 83. Though slowed by a stroke, he has worked up an Aerocar IV, which will use a Geo Metro auto for the car portion and a second engine for flight.

COURTESY MOLT TAYLOR COLLECTION

Taylor got some publicity through his own efforts, like storing the Aerocar in his garage (top), but when actor Bob Cummings acquired an Aerocar and featured it on his TV show, Taylor hoped sales would really take off.

Taylor is revered as a kind of patron saint of the flying car. "Oh, I had a ball," he says with a high-pitched chuckle. Visitors to his home in Longview hear his string of stories—like the time he got a speeding ticket in Florida while driving an Aerocar to an auto show. And once, while delivering an Aerocar to pilot and actor Bob Cummings, Taylor made a spur-of-the-moment stop at an Earl Scheib paint shop. After verifying that, yes, the $39.95 two-color rate was good for *any* car, Taylor had them match the yellow and green colors of Nutra-Bio, the vitamin company that sponsored "The Bob Cummings Show," on which the Aerocar would thereafter regularly appear in the early 1960s. Taylor himself has been on TV countless times. His favorite appearance? The time he drove the Aerocar onto the stage of "I've Got a Secret" and, with the help of an assistant and while answering the questions of the blindfolded panel, went about the car-to-plane conversion. "Three minutes later there was an airplane sitting there," he says.

Taylor was a gifted aeronautical en-

DAVID LEESON

SKY TECHNOLOGY

Even with its non-removable wings and elaborate winglets, Ken Wernicke's Aircar can still squeeze into a standard parking space. The scale model flies; the full-size version is currently for road demonstrations only.

gineer, "crazy about airplanes" from adolescence. In 1942, as a Naval reservist, he became the first person to successfully "fly" a surface-to-surface missile to its target, and the following year, as a lieutenant commander, he headed the project that produced the first generation of cruise missiles. His résumé also includes homebuilt aircraft like the Coot, an amphibious "floatwing" plane, and the Imp and Mini-Imp, two takes on a one-place sportplane with an inverted V-tail. An early version of an Imp helped launch his flying car quest. In 1946, while shopping for a plant in New Castle, Delaware, to build an amphibious sportplane he was then calling the Duckling, Taylor bumped into Robert E. Fulton Jr., soon to be heralded in *Life* magazine for his flying car, the Airphibian.

Taylor was impressed with Fulton's incarnation of a winged automobile—as was the Civil Aeronautics Administration, which later awarded it a type certificate, the first of only two flying cars ever certified for production (the other was Taylor's Aerocar).

"I saw it fly and watched him leave the wings and tail behind and drive off in the car," says Taylor. "I thought, *What a good idea. But I can do better.*" Taylor reasoned that if the whole idea of a flying car was that it would give you the freedom to go where you pleased when you pleased, then leaving behind the flight components was a less than optimal engineering solution. His design put the wings, tail, and rear-mounted propeller into a trailer towed behind the car.

To keep the weight down, Taylor fashioned the car's outer panels out of fiberglass, years before the Corvette startled the automotive world with its composite skin. And, because the rear wheels were used for landing, the Aerocar employed what was then an automotive oddity: front wheel drive. The toughest engineering challenge proved to be dampening the power pulses, or torsional resonance, in the 10-foot-long drive shaft connecting the Aerocar's Lycoming engine to its pusher propeller. After months of investigating vibration dampers, Taylor read about a little-known French dry fluid coupling called a Flexidyne. In this clutch, tiny steel shot was packed into a nearly solid mass that absorbed the engine's power pulses.

Taylor's Aerocar Incorporated turned out a prototype and four more examples of the design now known as Aerocar I. In 1961, Portland, Oregon radio station KISN bought one for traffic reporting. That was also the year Taylor first glimpsed a bit of financial blue sky. He'd struck a deal with Ling-Temco-Vought, a Dallas-based company. They'd build 1,000 Aerocars at a projected cost of about $8,500 apiece, provided he could round up 500 firm orders. In two weeks he collected 278 deposits of $1,000 each and forwarded the money. But without another 222 orders, the deal fizzled.

Nine years later, Taylor's hopes rose again when Ford Motor Company took an interest in the Aerocar III. (The Aerocar II was a four-passenger flight-only fuselage.) The Model III had fully retractable wheels, which cut drag and boosted cruise speed 10 percent to nearly 120 mph. Lee Iacocca sent Donald Petersen, a vice president of product planning and research (and later the company's chairman), and Dick Place, a Ford executive with a pilot's license, to meet with Taylor in Longview.

Place's logbook dates his Aerocar flight to August 1970. He recalls being sufficiently impressed with both the flight and highway performance to suggest that Ford "at least take the next step or two investigating the possibilities." But in the face of the oil crisis and increased importation of Japanese cars, the company's interest cooled. And Place speculates that the career-minded Petersen probably didn't want to be "weighed down with advocacy of what most people would think of as a harebrained device."

Taylor made headlines with his Aerocars, but no money. In his basement is a huge library of videotapes, most of them made from Super-8 footage. "Look at it go, boy," he says. "Now watch how smooth it lands." There's Taylor, wearing a fedora, standing on the old sod runway. He hears himself pounce on an interviewer's question: "If it weren't for us nuts, you'd still be reading from candlelight and wearing button shoes.... The flying automobile is the future. It

To Build a Better Mousetrap

The marriage of automobile and airplane began early in the history of both vehicles. In 1917, just 14 years after the Wrights first flew and nine years after Henry Ford introduced the Model T, visitors to the Pan-American Aeronautic Exposition in New York City gaped at a hybrid called the Autoplane. Built by the Curtiss Aeroplane and Motor Company, the Autoplane was a three-seat car design (in front sat a pilot/chauffeur, hence the nickname Flying Limousine) topped with triplane wings spanning 40 feet. It flew, but never well enough to muster serious interest.

In 1937 airplane designer Waldo Waterman rekindled interest in a flying car with his Arrowbile, a refinement of an earlier attempt he'd called the Arrowplane. Its three-wheel design sufficed for short drives to the airport; it fared worse on the open road. Airborne, it was said to be nearly stall-proof and impossible to spin.

The 1940s was the golden age of the flying automobile. The post-World War II boom in private aviation gave birth not only to Molt Taylor's Aerocar but to Robert Fulton's Airphibian in 1946 and the ConVairCar the following year. Fulton's craft flew well enough to be certified by the Civil Aeronautics Administration, and, with its propeller detached and flight unit removed, drove well enough to negotiate city traffic. The ConVairCar concept added a new twist: It topped a two-door sedan with a flight unit containing its own powerplant, which car owners would rent at the airport. Its creators talked of cars priced at $1,500 based on production runs of 160,000, but talk ended after the ConVairCar crashed on its third flight, out of fuel because its pilot had reportedly eyed the auto fuel gauge instead of the aero gauge.

In the 1950s and '60s, Leland Bryan produced a series of highway-certified folding-wing Roadables that used their pusher propellers for both air and road power. Bryan died in the crash of his Roadable III in 1974. And in 1973, Henry Smolinski, mimicking the ConVairCar rental unit concept, fastened the wings, tail, and aft engine of a Cessna Skymaster to a Ford Pinto. The wing struts collapsed on its first test flight, killing Smolinski and the pilot.

HOWARD LEVY

NASM

Robert Fulton's 1946 Airphibian (above) inspired Molt Taylor to build the ideal roadable airplane, but flying cars got started 30 years earlier: Curtiss Aeroplane debuted its Autoplane (above, right) in 1914. Waldo Waterman's 1937 Arrowbile (below) flew well enough but drove poorly. The 1950s Bryan Roadable (below, right) employed folding wings. The Mizar, the mating of a Ford Pinto and a Cessna Skymaster (right), crashed on its first flight in 1973.

HENRY ARTOF

BETTMANN ARCHIVE

BETTMANN ARCHIVE

DAVID SANCE (2)

Roger Williamson believes that a kit-built craft will make the roadable airplane a reality. After working up a variety of designs (left), he based his low-wing tricycle-gear Roadrunner on the model in the foreground.

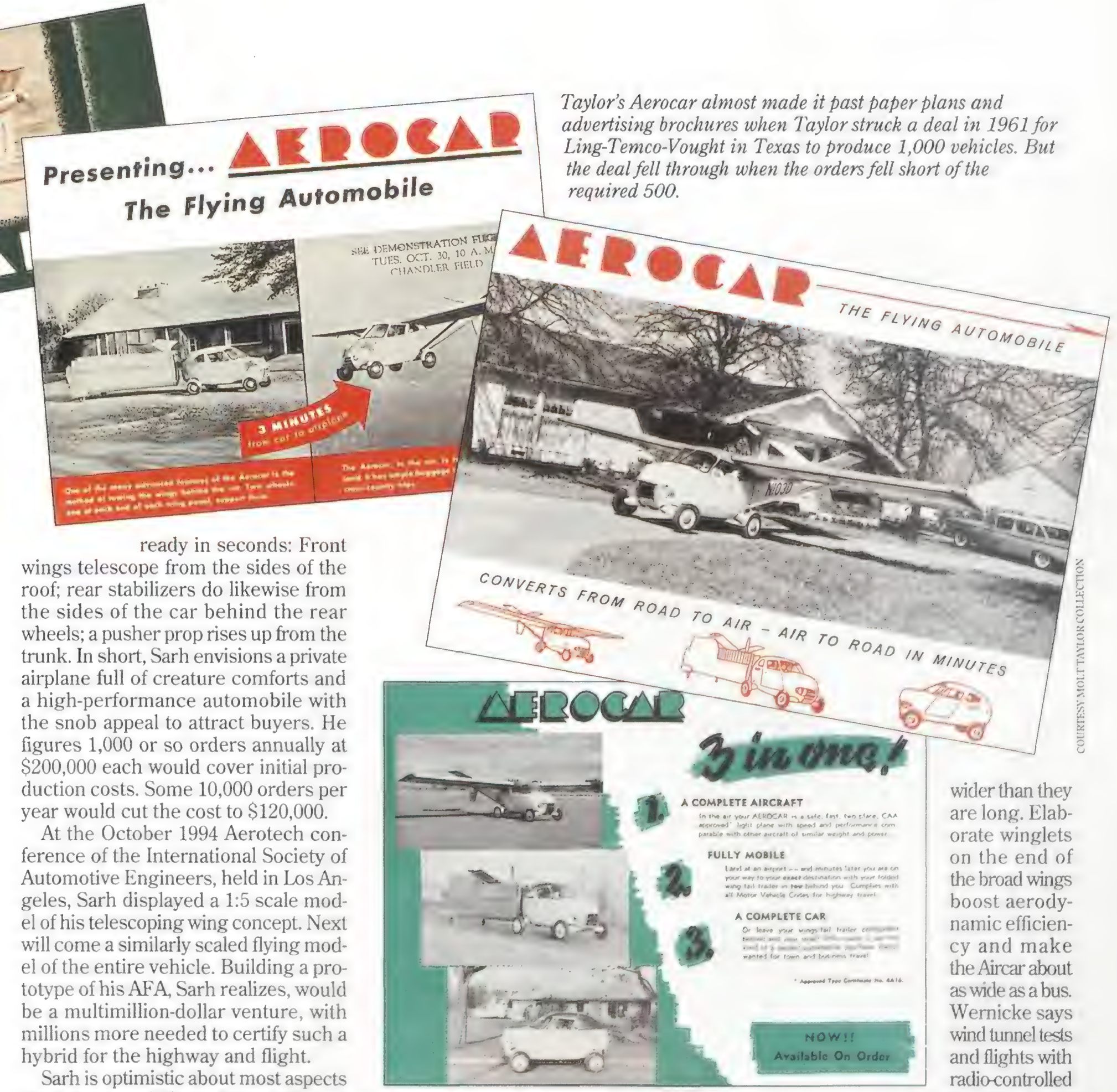
has to be, just as sure as they made wagons without horses."

Taylor chuckles, then says forcefully: "I still believe that."

"To me, it's simply a question of time," says Branko Sarh, a senior engineer at McDonnell Douglas Aerospace in Long Beach, California. As a teenager in Germany, Sarh was sketching flying car designs long before he ever heard of Molt Taylor. He studied aircraft and automotive design in college, and at the Massachusetts Institute of Technology in the early 1980s he began concentrating on composites and automation, two key elements of his futuristic Advanced Flying Automobile.

"If someone today says flying cars, everyone looks backward, into history," Sarh says. "Oh, they were produced already: Curtiss and Taylor and Con-Vair. All these were excellent pioneering efforts. It was perfect to prove that a car can fly, but that's all they proved." Sarh feels the time is ripe—thanks in part to recent advances in lightweight composites and computer modeling techniques—for a major leap, well beyond some warmed-over newsreel version, to an entirely new flying car concept. His design, unlike most, puts the car before the airplane. His reasoning: "People will mainly see this vehicle on the ground. This must be a perfect car, first of all. The styling must be superb."

His four-passenger AFA, designed with the help of Merkel Weiss, an automotive engineer who teaches at the Art Center College of Design in Pasadena, California, appears both sleek and stylish and boasts front and rear seat airbags, air conditioning, and a shifting diagram of P to R to N to D to F. At the push of a button, the car becomes flight-



Taylor's Aerocar almost made it past paper plans and advertising brochures when Taylor struck a deal in 1961 for Ling-Temco-Vought in Texas to produce 1,000 vehicles. But the deal fell through when the orders fell short of the required 500.

COURTESY MOLT TAYLOR COLLECTION

ready in seconds: Front wings telescope from the sides of the roof; rear stabilizers do likewise from the sides of the car behind the rear wheels; a pusher prop rises up from the trunk. In short, Sarh envisions a private airplane full of creature comforts and a high-performance automobile with the snob appeal to attract buyers. He figures 1,000 or so orders annually at $200,000 each would cover initial production costs. Some 10,000 orders per year would cut the cost to $120,000.

At the October 1994 Aerotech conference of the International Society of Automotive Engineers, held in Los Angeles, Sarh displayed a 1:5 scale model of his telescoping wing concept. Next will come a similarly scaled flying model of the entire vehicle. Building a prototype of his AFA, Sarh realizes, would be a multimillion-dollar venture, with millions more needed to certify such a hybrid for the highway and flight.

Sarh is optimistic about most aspects of his Advanced Flying Automobile, except locating the money to fund it. He hasn't even bothered to approach a car or airplane manufacturer. "Automotive companies simply don't have the aircraft experience, and airplane companies don't have any automotive experience," he says. He dreams of a benefactor "who wants to show the world he can create something."

A similar lack of funding has stalled Ken Wernicke's Aircar, which last year made the covers of both *Popular Mechanics* and a special issue of *Discover*. Known as "Mr. Tiltrotor" at Bell Helicopter Textron, where he worked for 35 years, Wernicke was lead engineer on the XV-15 and director of the V-22 Osprey Tiltrotor. He took early retirement in 1990 and formed Sky Technology, based in Hurst, Texas. He put its mission right on the company's letterhead: Specializing in Revolutionary Aircraft. Case in point: the Aircar.

Wernicke's design sidesteps car-to-plane and plane-to-car transformations by using low-aspect-ratio wings that are wider than they are long. Elaborate winglets on the end of the broad wings boost aerodynamic efficiency and make the Aircar about as wide as a bus. Wernicke says wind tunnel tests and flights with radio-controlled models show he's on track. He's drummed up media interest by driving around in a full-scale mockup that's eight and a half feet wide and shoehorning it into standard parking spaces.

And that's where he remains—in park. Meantime, he's test flying a 1:3 scale model. He figures he'd need $3 million to build two proof-of-concept vehicles, one for flight certification, a second to present to the National Highway Traffic Safety Administration. "I think if we could fly it, we could sell it to some

JEFFREY ISOM/EAA (2)

aircraft manufacturer," he says, "though it might have to be a foreign one, like Samsung Aerospace of South Korea." He admits, though, that highway approval has him worried.

Book 49 of the Code of Federal Regulations for automobiles invokes more than 700 requirements in some 50 categories, specifying everything from crashworthy bumpers to emissions standards to proper headlight beam patterns. But would all this have to apply to a flying automobile? Barry Felrice, associate administrator for safety performance standards at the NHTSA, suggests it might not. "Our standards apply to motor vehicles which are used primarily on public roads," says Felrice. In other words, if a flying car—or, to better make the case, a roadable airplane—were to spend, say, more than half its time aloft, it might be considered in the same off-road category as earth moving equipment and airport runway vehicles.

If Sarh's and Wernicke's concepts represent the high end, Roger Williamson's design embodies the low-road approach. Williamson, a retired Air Force fighter pilot who toils away in his San Antonio garage and admits, "I'm no engineer," believes a kit-built design like his low-wing Roadrunner is a more practical approach to making the flying car a reality. "I think if it's going to be done, it's got to be homebuilt, as simple as possible and as economical as possible," he says. "We all look at life from our own perspective. I don't have much money and I need a plane I can park in my garage."

Projected kit-built costs: around $25,000. Williamson, who has built four three-wheel cars, figures his three-wheel roadable aircraft will have an easier time meeting highway safety standards if it's classified as a motorcycle. "I'm sure there's going to be some eyebrows raised," he says, "but no law I know of says what a three-wheeled vehicle has to look like."

Williamson has spent $10,000 and has yet to shop for the used four-cylinder Rotax aircraft engine that he estimates will enable cruising speeds of 150 mph. Yet he works on. "It's a stupid waste of time," he says, "but when you're hooked, you're hooked."

There's also the re-hooked. Ed Sweeney, the Molt Taylor student who never lost his interest in model airplanes, went on to publish *American Aircraft Modeler* and *RC Sportsman*. After that he manufactured ultralights. He owns four Lotuses, an electric car, and, as he puts it, four and a half planes.

In 1988, Ed and Sandra Sweeney saw an ad in Trade-A-Plane *and snapped up the Aerocar that Ed had flown with Taylor in 1959. Having made it airworthy again, they've logged some 200 hours aloft.*

In 1988 Sweeney's son handed him the latest issue of *Trade-A-Plane*, urging: "Look at this ad for a Messerschmitt 109, Dad. Shouldn't we buy it to go along with our 209?" Sweeney was immediately on the phone, but not about the Messerschmitt. His gaze had fallen on an adjacent ad for an Aerocar. The next day he met with its Florida owner, who had been trucking it around as a static display. Sweeney prefers not to reveal the purchase price, which was somewhat blurred because the deal included a swap of autos. Suffice it to say he paid well in excess of Molt Taylor's original asking price of $15,000. Sweeney found it hard to hide his eagerness, especially after the Aerocar's logbook confirmed his suspicion: this was N102D, the one Bob Cummings had owned, and the same Aerocar he'd flown with Molt Taylor in 1959.

It wasn't just the vehicle that passed to Sweeney; in a sense it was also the Aerocar torch. After Sweeney had made the craft airworthy again and repainted it in the Nutra-Bio colors, he took it to airshows. He flew it for a Japanese film crew. He's logged about 200 hours in it, and flying it to Miami from his former home in the Florida fly-in community of Spruce Creek, he has experienced the convenience of landing and driving off to his destination. And he is at work on another flying car.

"We're taking existing ideas and putting them all together," Sweeney says. "Everything about the future Aerocar exists today." Paying homage to Taylor, Sweeney is calling his design Aerocar V. He also plans to use a Geo Metro, though a convertible in his case.

CARL SCHUPPEL/EAA

Taylor's Aerocar still serves as an inspiration for the new generation of roadable designers and dreamers.

to help facilitate hookup of the wing and tail section and flight components. Like Taylor, whose current design calls for a kit-built vehicle, Sweeney envisions giving his Aerocar V customers the option of cutting its weight by substituting composite panels. He also projects a second engine in the attachable airplane section and an inverted V tail. "We're looking at an empty weight of 2,840 pounds," he says, acknowledging a problem in getting the weight down to light-aircraft standards of about 2,000 pounds. But he breaks with Taylor on one key point.

"I'm not keen on trailering. I've done it with the Aerocar and I don't want to do it very often," Sweeney says, explaining those "real time" conversions Taylor enjoys showing off on film were accomplished under optimal conditions, guided by tape marks on the floor. Sweeney says he's spent more like 45 minutes on some conversions. "The whole idea of the flying car is to stay in motion, like a UPS or FedEx package," he says. "It needs to be less than 30 seconds to convert from car to airplane. If it's over that, the public wants no part of it."

Resurrecting the 1947 ConVairCar concept of airport-available airplane attachments, Sweeney envisions future Hertzes or Avises renting attachable airplane portions at airports. This vision is shared by Steven Crow, a professor of aerospace engineering at the University of Arizona. Crow's a member of the flying car fraternity—he calls his design the Starcar. He's working on using the Global Positioning System of satellite-based navigation to enable computer-piloted flying cars to maintain safe distances from one another. He imagines skyports located along interstate highways.

"Transform stations will resemble car washes but will be staffed by robots," he writes in a proposal titled "Back to the Future of Personal Aviation." "The traveler will drive toward a station entry and announce his destination by keypad. A robot will test data links and controls of the passenger module, while another fuels and trims a flight module for the journey.... The flight module will have GPS-based navigation and control equipment capable of negotiating the journey from takeoff to landing with no intervention by the traveler." Others share Crow's vision of automated flying cars, maintaining that most of the technology already exists and deeming computer-controlled flight more realistic than training and licensing the masses as pilots.

Before any of this is possible, the public will need to be re-romanced with a few flying cars soaring overhead. Sweeney hopes that's where he'll come in. He's spent hours modeling designs and running calculations on a computer, and additional weeks fashioning and flying scale models. Next he hopes to build a 1:4 version with sensors that will enable him to record and download flight data to a computer. He says he's committed to spending the next six years and up to $100,000 of family money on flight testing a full-scale prototype. "I'll build one," he says almost defiantly. "Then we'll see what happens." Sweeney was recently asked to join the Advanced General Aviation Technologies Experiment, a NASA-Federal Aviation Administration consortium designed to revitalize general aviation.

His voice drifts off. "Every time we've been to Oshkosh with the Aerocar and every time I've flown it to an aviation event, people keep coming by and saying, 'My Glasair, or whatever, is neat, but I don't use it that much. It was fun to build it, but it's not useful.' Pretty soon we're talking about a new Aerocar, and the question is always: How soon can I order one?"

THE ROAD SHOW

by Brian Duff

Thirty years ago, astronauts were an exotic species. Wherever they appeared, crowds went wild.

In 1963, New York City hosted a parade for Mercury astronaut Gordon Cooper, the fourth American in space. The celebration attracted four and a half million people—and left 2,900 tons of ticker tape and confetti covering the streets (opposite). After 1965's Gemini 4 mission, in which Ed White became the first American to walk in space, White, Vice President Hubert Humphrey, and White's crewmate, Jim McDivitt, led a parade through the streets of Washington, D.C. (above).

When space travel was new and astronauts relatively rare, people knew the names of those who ventured into space. Public enthusiasm was personal, and people lined up to get autographs or even just a glimpse of the returning space heroes. The ardor seemed even more intense overseas, where the cool competence of the astronauts and cosmonauts seemed to strike a chord. Some speculated that space travel (touted as civilian programs by both nations) allowed foreigners to admire the accomplishments of the two superpowers without subscribing to their policies or military programs.

Whatever the reasons, in the mid-1960s, the U.S. Department of State took full advantage of this popularity, sending the astronauts and their wives on goodwill tours to dozens of countries in Africa, Asia, and South America. Even in countries where U.S. policies were unpopular and visiting politicians had been vilified, the astronauts and their wives seemed to get a special exemption. They met the heads of state, visited university campuses, and laid wreaths on countless tombs of unknown soldiers. In every case, they were treated with respect and friendship. Back home, major American cities still honored the astronauts with elaborate parades, and in financial districts such as New York's Wall Street, crowds cheered as swirls of ticker tape and showers of red, green, and blue confetti floated down among the densely packed buildings.

As the astronauts moved through the throngs in parades around the world, the affection and admiration became a physical force that was almost frightening. People pushed and shoved one another as they tried to embrace the astronauts, shake their hands, or just touch their clothing. Often it took swift intervention by local police to keep the astronauts from being overwhelmed. A New York mounted police officer once plucked Gordon Cooper out of a crowd by pulling him up on his horse. In Athens, Greece, it took a line of hotel employees with linked arms to get the astronauts through the crowd to their motorcade. When I traveled with the astronauts and their wives as a NASA public affairs officer, I kept thinking to myself, *This is what it must be like to travel with the Beatles.*

NASA (2)

A BIG DAY IN STEELTOWN

Thirty years ago, the once-booming steel town of Gary, Indiana, was in the midst of a deep depression caused by the closing of the big mills. Gemini 7 astronaut Frank Borman had been born in Gary, but he grew up in Arizona and claimed Tucson as his hometown. Even so, Gary officials pleaded with NASA to send Borman back after his spaceflight, ostensibly to honor him but mostly to give the stricken city some reason to celebrate. The Indiana Congressional delegation turned up the political heat and NASA gave in. Borman would have two hometown celebrations: first Gary, then Tucson. When I flew into Gary to consult with city officials about Borman's visit, I was treated as if I had brought

AP/WIDE WORLD PHOTOS

serum to a city ravaged by plague. At every level of the city administration there was an eagerness to please and an almost heartbreaking determination to make the astronaut visit a success.

Fortunately for Gary, it had drawn the right astronaut. Borman may have gone to Gary with faint enthusiasm, but once committed to an assignment he did his best. And of all the astronauts, he had the greatest gift for reaching the public. Newsmen marveled at Borman's ability to rise in a crowded hall, assess his audience, and speak directly and eloquently to the interests of his listeners. Borman was outgoing and personable and seemed to exude integrity, and his wife, Susan, was blonde and beautiful. When the two walked or rode through the streets holding hands like high school sweethearts, the battered citizenry fell in love. For one day at least, Gary forgot its troubles, and the sun lit up the town.

When the day ended, I sought out Gary's police chief, Conway "Moon" Mullins, to congratulate him on the performance of his city and his department. I found Mullins in the cocktail lounge of the astronauts' hotel. He was already several martinis into a celebration of his own, but he was not too far gone to respond to praise from Washington. After I had complimented his department, the chief leaned close and whispered: "You're damn right there were no problems, 'cause we rounded up every troublemaker in Gary last night and threw them all in jail."

While I pondered the implications of this revelation, the ecstatic lawman threw his arm around me and added: "You guys were terrific. Here's a little token of my appreciation." With that the chief pressed two room keys into my hand. When I looked around for guidance, a police lieutenant, smothering his laughter, explained that the chief had selected two of the more presentable prostitutes from the previous night's raid and sequestered them in the hotel. I stared at the two keys in my palm and groaned. *My god*, I thought. *He's put them on the same floor as the Bormans!*

"I WANT Y'ALL TO GO TO PARIS"

Ed White, who was later to die with Gus Grissom and Roger Chaffee in the Apollo 1 fire, was the first American to walk in space. In 1965 people around the world responded to a dramatic photograph, taken by fellow Gemini 4 astronaut Jim McDivitt, of White in his spacesuit floating at the end of

a long golden "umbilical cord" in the black void of space. The two Air Force lieutenant colonels had attained star status, and that dictated a weeklong U.S. tour, culminating in a triumphant welcome at the nation's capital. In the final hours of a busy final day, the astronauts were on stage at the state department providing commentary while films they had made during their flight were shown to members of the international diplomatic corps.

Suddenly there was a rustle of activity as Secret Service agents moved quickly into flanking positions along the sides of the auditorium. Then the rear doors burst open and President Lyndon Johnson, wearing a brown tuxedo, strode in. A place was quickly made for him in the front row between Vice President Hubert Humphrey and NASA Administrator James Webb. When the movies were over, Johnson stood up and, in a voice that carried through the auditorium, drawled: "Gentlemen, if I had seen your films before I saw you last week in Houston, I might have promoted you to full colonels." As the laughter and applause died down, Johnson added: "Gentlemen, I want y'all to go to Paris as quickly as possible, and take your lovely wives with you."

The astronauts looked at each other in disbelief, but the president wasn't finished. He looked down at Humphrey, who was also chairman of the Space Council, then at Webb, and said: "Hubert, you go along with them, and you go too, Jimmy. Take your wives. You can use my airplane." Finally, Johnson turned back to the two astronauts on the stage and said: "When you get finished here come back to the White House for a drink before you leave." With that he loped back up the aisle and out of the auditorium, leaving the program in a shambles. We learned later that the president had come to the state department on a rescue mission for the U.S. aerospace industry. Executives had been calling the White House from France all week to report that the American presence at the Paris Air Show was being overwhelmed by spectacular performances by the Soviets, including an appearance by cosmonaut Yuri Gagarin. The U.S. aerospace leaders wanted the administration to field a dramatic countermeasure.

By plan or by luck, the president had picked the perfect venue to accomplish his objectives with maximum impact and dispatch. While the astronauts and their wives were still greeting the members of the diplomatic corps in a receiving line, state department photographers snapped their pictures for diplomatic passports. Meanwhile, a senior foreign service officer who had set up shop in the basement was assembling passports for everyone in the official party, which had grown to about 40 persons. Since most of those who would be traveling were still upstairs at the reception, they were not available to answer routine questions about the color of their eyes or their hair. "We'll waive all that," the official decided in frustration, handing me a thick bundle of black passports. "Just don't let anybody in France see these if you can help it, and I want them all back when you come home." At the same time, the Secret Service was firming up plans to move the vice president and the astronauts and their wives from the White House, where they were having their nightcap with the president, to Andrews Air Force Base in suburban Maryland, where the airplane was being readied for departure.

The swift-moving events that night were an impressive

UPI/BETTMANN (2)

Astronauts' Paris Visit Steals Show From Russians

By Garven Hudgins

PARIS, June 19 (AP)—Vice ...sident Hubert H. Hum... ...and the Gemini astro... Humphrey led White, McDivitt and their wives on a quick tour of the Soviet pavilion, where the meeting with ... luncheon for 4,275 guests held in a hangar at Le Bourget Airport.

Humphrey earlier met with ... ...tary Premier Georges Pompidou was host at the luncheon. Humphrey is scheduled to ... meet with President de Gaulle Sunday before returning to Washington.

His Gemini 7 flight earned Frank Borman top billing in a parade in his birthplace, Gary, Indiana, a town that really needed a reason to cheer (opposite).

In 1965, President Johnson sent the Gemini 4 astronauts to the Paris Air Show on a public relations mission (above, left to right: Ed White, wife Pat, Vice President Humphrey, and Jim McDivitt). At the Paris show the Russians insisted that cosmonaut Yuri Gagarin was too busy for the astronauts, but the space explorers still managed to meet up (right; from left: Gagarin, Humphrey, White, and McDivitt).

UPI/BETTMANN (FAR LEFT); AP/WIDE WORLD PHOTOS

While overseas, astronauts did their best to please their hosts. Left to right: Wally Schirra and wife Jo tried their hand at chopsticks in Tokyo, Frank Borman received an award from Philippine president Ferdinand Marcos, and Gordon Cooper hit the dance floor at a party in Nigeria.

display of presidential power. The two astronauts and their wives, Humphrey, Webb and his wife, and various other dignitaries departed the White House lawn just hours after the president ordered the trip. As the helicopters lifted off in the darkness from the White House lawn, the president's daughters, Lynda Bird and Luci Baines Johnson, who had volunteered to help babysit, stood in their nightclothes with the astronauts' children waving goodbye.

How the U.S. Ambassador to France, Charles Bohlen, reacted when he was awakened in Paris with the news can only be imagined. In addition to having to instantaneously create a week of activities for the incoming astronaut party, he had the thankless job of informing French president Charles de Gaulle that the American vice president and two U.S. space heroes would arrive in France within hours. De Gaulle reportedly was so incensed at what he took to be a flagrant breach of protocol by the U.S. president that at first he refused to receive either Humphrey or the astronauts. But of course we knew none of this as we disembarked in Paris, groggy from lack of sleep, and filed to the waiting limousines down a long red carpet flanked by guards with plumed helmets, gleaming breastplates, and drawn swords.

The feelings of the French president might have been bruised, but the average Frenchman was charmed by the boyish space heroes and their wives. With Humphrey at their sides, the astronauts worked without a break: touring the airshow, lecturing, attending receptions, and appearing on French television programs. When they volunteered to answer questions on a radio talk show, the incoming calls temporarily shut down the Paris telephone exchange. The pair even cornered cosmonaut Yuri Gagarin one day. Photographers snapped pictures while the Americans and the Russian talked in two languages augmented with a lot of pilots' sign language.

By the end of the week, Johnson's grandstand gesture had paid off. Any American tourist in a Paris taxicab would first be asked if he knew the astronauts and then be treated to a sweep across the cab's radio band to hear, over and over, "astronaut…astronaut…astronaut." By the end of the week, the icy de Gaulle succumbed to political reality. Humphrey and the astronaut families were invited to the presidential palace for an audience. The Americans said later that de Gaulle was polite, cool, and very, very tall.

KINGS, QUEENS, AND EMPERORS

As the astronauts traveled the world, they became the nation's goodwill ambassadors and met with the leaders of nearly every country they visited. Such encounters often presented unique questions of etiquette, but the astronauts usually rose to the occasion with the same spirit they had brought to dealing with the unknown in space.

Jim Lovell and Pete Conrad, who had made separate Gemini flights in 1966, were teamed up by NASA and the state department to tour Africa. Lovell had let his beard grow during his four-day Gemini 12 flight, but he was clean-shaven when he met Ethiopian emperor Haile Selassie. When the emperor saw Lovell, he reached out and touched his face. The bearded ruler was simply telling Lovell that he preferred him in a beard, but because the emperor was venerated as a god by many of his followers, this intimacy with a mere mortal sent a shock wave through the courtiers in the room.

Lovell and Conrad also met the Oba of Benin. The Oba,

who lived in a palace in Nigeria, was the religious leader of hundreds of thousands of people and was said to be the 37th descendant in his line. The astronauts and their wives paid particular attention to the furnishings during their visit to the Oba. They had been told that at least one of the chairs in the audience chamber was upholstered with the skin of a Portuguese slave captain caught cheating one of the Oba's ancestors, but no one spotted the fatal chair with any certainty. The Oba listened to the astronauts attentively but with little expression. When they had finished explaining a little about spaceflight, the religious leader had only one question about their journeys: "Did you see any angels?"

NASA/LBJ LIB.

After the rendezvous of Geminis 6 and 7, Frank Borman and Wally Schirra made an Asian tour, and in Thailand they met the king and queen. Although the rulers were quite progressive in private life—he drove sports cars and played jazz—court protocol was to be strictly observed during the audience with their majesties. We were warned, for example, that it was bad form to cross one's legs so as to expose the soles of one's feet. Thus it was a relief to be met by a uniformed admiral of the Thai navy complete with aviator's wings and flight experience in U.S. jet fighters.

Reassured by the presence of the admiral, we were almost relaxed as we were escorted into the throne room. The king and queen sat side by side on a raised dais. We were seated in what seemed to be unusually low gold chairs. By prearrangement, each of us watched the other to make sure no one crossed his legs. I soon noticed that the servant pouring orange punch into a glass by my side was doing so from a prone position on the floor. It was then that I realized that only we, the honored guests, were seated—albeit somewhat lower than their majesties. Even the Thai admiral, still resplendent in dress whites, was reclining on one hip. We were all very much aware of the historic nature of the occasion, and though the royal couple seemed genuinely interested, it was hard to relax under the circumstances.

Finally, the audience ended, and we all stood as the king and queen rose to bid us goodbye. But we still had one more hurdle to clear. We had been instructed to back out of the throne room, since it was a serious breach of protocol to turn one's back on their majesties. One by one we made it, groping our way past the little gold chairs and potted palms. Everyone did splendidly except me. At the last minute, panicking that I had missed the door, I glanced over my shoulder. One of our embassy handlers shot me a dirty look.

Having a sense of humor helped us get through the potentially awkward situations we faced every day, but Schirra's sense of humor was sorely tested when we reached South Korea. When the motorcade reached the Presidential Palace for a visit with President Park Chung Hee, Schirra, the last to emerge from the limousine, stumbled slightly and, reaching back to steady himself, curled his fingers around the centerpost of the car. At just that moment I was closing the front door, and it slammed against one of the fingers of his left hand. Schirra winced and groaned, but he shook off my distraught apologies and mounted the steps of the palace with his uninjured right hand outstretched to shake hands.

What followed was an excruciating hour for the astronaut as he, Borman, and their wives met with the Korean president. Schirra said later that the only thing that got him through the ordeal was a cotton ball soaked with anesthetic that had been slipped to him by an alert Korean physician. Once back at the U.S. Embassy, a doctor pierced Schirra's nail to relieve the pressure and the pain, and by the time the astronauts reached New Zealand on the last stop of their tour, the nail, although blackened, was clearly healing. This did not, however, stop Schirra from saluting me on every possible occasion by holding up his fist with the injured middle finger extended upward and saying loudly: "I think it's going to be all right."

ON PARADE, OUTBACK-STYLE

Although the astronauts got affectionate welcomes everywhere, certain countries had special feelings for them. Australia, the site of a NASA tracking station frequently visited by astronauts on working trips, was at the top of the list. When Schirra and Borman came to Australia for the first official visit, their welcome was literally fit for royalty. The Australians had rolled out the pair of plum-colored Rolls-Royce convertibles procured for an earlier visit by Queen Elizabeth. These beautiful automobiles had yellow pigskin upholstery and a silver handrail so the monarch could steady herself as she stood to acknowledge the cheers of the multitudes. One of the cars was airlifted ahead and waiting in each of the major cities we visited.

When we visited the remote rocket test facilities near Carnarvon, however, the authorities apparently decided the limousines would be inappropriate. Nevertheless, that little town's sun-baked residents, upon receiving the state department's instructions recommending a parade, had decided to do their best to accommodate the odd ways of the Yanks. When we arrived, the welcoming committee showed us a flatbed truck with a railing around the sides and a rope


Chicago Tribune
THE WORLD'S GREATEST NEWSPAPER
CITY FINAL
SUNDAY, JUNE 26, 1966
SALUTE TWO SPACE HEROES

stretched down its length. This, it was explained, would be our float in the parade and also take us to a restaurant in the nearby countryside for lunch and the required speeches and presentations.

Schirra and Borman were unflappable by nature and may have welcomed a recess from the high ceremonials of earlier stops. At any rate, we all jumped up and got a grip on the safety line. The procession moved sedately enough for the first few blocks, with the astronaut vehicle near the lead. Then the pavement ended. As soon as the truck hit the dusty country roads it kicked up a thick cloud of yellow grit. One by one, the cars full of dignitaries and guests passed our truck, waving as they went by. We were left standing in swirls of dust throughout the long ride to the inn.

When the jolting journey finally ended and we climbed stiffly down to solid ground and stumbled into the cool sanctuary of the restaurant, we all looked like late finishers in a cross-Australia road rally, covered with dust from our hair to our shoes, eyes blinking out of masks of grit. It was never quite clear whether the Australians neglected to notice our condition out of politeness or just thought the whole thing was a wonderful joke on the Americans. In any event, foaming mugs of beer were passed around, and we found ourselves surrounded by sunburned, oversized Aussies whose affection and admiration were unmistakable. Schirra and Borman looked at their windblown wives and at each other. After shaking their heads and pausing, all four broke out laughing. Later we all agreed that this was the way to see the *real* Australia—not lounging in a plum-colored Rolls-Royce but eating dust in the back of a truck.


UPI/BETTMANN


NASA (2)

Frank Borman, who flew on Apollo 8, the first manned mission to orbit the moon, gave the pope a lunar portrait during a private meeting at the Vatican in 1969 (top).

Even before he made it into space, Gordon Cooper was famous: Three days before his 1963 Mercury MA-9 flight, autograph seekers flocked to him at a church in Cocoa Beach, Florida.

EVERYDAY CRISES

In a space of about two years the Gemini astronauts visited more than 50 countries and dozens of U.S. cities. The schedule became so frantic that most of the details, for me at least, became a blur. Usually it was some minor crisis that would stay clear in my memory. Like the time the astronauts' convertible ran out of gas in the middle of a parade in Santiago, Chile. Or the time we realized, on the way to visit the president of Colombia in Bogotá, that the name of his country was misspelled on his gift. Or the unusually large and boisterous crowd in Izmir, Turkey, which turned out to be swollen with people who had come to see not "men who were *going to* the moon" but "men who were *from* the moon."

And then there was the press coverage Gordon Cooper and Pete Conrad got in Panama on an unscheduled stop. The local newspaper gave extensive coverage to their surprise visit but apparently did not have a picture of Cooper or Con-

Wives and friends of Gus Grissom and John Young cheered as Gemini 3 took off on a five-hour mission in 1965.

In South Korea, the author, Brian Duff, accidentally slammed Wally Schirra's finger in a car door frame. Years later, Schirra gave Duff a memento showing that his finger was just fine.

rad. No problem. The next morning the newspaper ran a picture on the front page of a man in an old-fashioned diving suit, complete with air hoses and a round brass helmet. Under the picture of this unknown deep-sea diver was the caption "Astronaut Gordon Cooper."

ONE LAST HURRAH

The late Richard A. Daley was one of the last political bosses of a major American city. His control of Chicago during his long tenure as mayor (the current mayor is his son) was personal and mostly unquestioned. Daley embraced the early astronauts because they gave him an excuse to stage a seemingly endless series of all-American parades through Chicago's Loop. Other cities had provided extravagant welcomes for the early Mercury astronauts, but by the time of the two-man Gemini flights, the spectacles were beginning to go out of fashion. Even NASA was downplaying repetitive parades in major cities, turning instead to smaller hometown celebrations for individual astronauts. Julian Scheer, the agency's chief of public affairs, had issued a dictum: "One parade too few rather than one too many."

But Daley would hear none of it. Gemini 9 astronaut Eugene Cernan came from one of Chicago's suburbs, and Daley had decreed a "Gene Cernan Day" complete with a parade for him and his fellow Gemini 9 astronaut, Thomas Stafford. I was sent to Chicago to talk the mayor out of it or at least make sure the event was not an embarrassment.

In those days all public events in Chicago were run by Colonel Jack Reilly, a long-time Daley staff man. The colonel, a colorful fellow, wore a wrinkled trenchcoat, a snap-brim felt hat, and a black patch over one eye. In most cities where NASA's public affairs advance men had worked, relations with officials were cordial and cooperative; authorities treated us with some deference, perhaps assuming the agency's technological competence carried over into public relations. Reilly had no such illusions. When I suggested that it might be prudent to confine the celebration to Cernan's hometown of Bellwood in case no one showed up, Reilly swiveled his single eye and grated: "There will be a crowd." And then, taking pity on his backward pupil, he added: "The parade is at *noon*! You can't change a tire in the Loop at noon without drawing a crowd!"

The colonel was absolutely right. On the day of the event, NASA fulfilled its only real function by delivering the astronauts and their wives to the right place at the right time. Chicago reciprocated with a turnout both large and exuberant. There was no detectable diminution of fervor. When it was all over, the colonel and I stood together for a few minutes on the sidewalk. Then he jerked his thumb at me and led me around the hotel to a back street. Stretching for blocks were rows of yellow school buses that had been used to bring the party faithful downtown for the parade. "Insurance," said the colonel with a wintry smile.

COURTESY BRIAN DUFF

Times have changed since that day in Chicago. Few people can name a shuttle astronaut, except maybe one who died in the *Challenger* explosion, and some actually have trouble recalling the name of the first man on the moon. And the old-style parades are long gone—even if the astronaut craze hadn't faded, we could never re-create them. Computers have replaced the machines that generated ticker tape, and the windows of Wall Street's air-conditioned buildings probably don't even open anymore. In the 1960s, Colonel Reilly didn't really need to drum up a crowd for an astronaut parade—he was just covering his bases. These days, though, he'd have to have those buses ready.

PHOTOGRAPHS BY ROLAND MILLER. ALL PHOTOGRAPHS TAKEN AT CAPE CANAVERAL AIR FORCE STATION. LEFT: "ABANDONED IN PLACE." COMPLEX 34, 1991

"GROUND," COMPLEX 13, 1991

BOLTS, COMPLEX 13, 1991

>SIGHTINGS<

At 5:30 a.m. on a humid Florida morning, I leave my apartment to drive to Cape Canaveral. By sunrise I will be taking pictures of the Cape's deactivated launch complexes. The Mercury, Gemini, and Apollo missions launched from these facilities captivated the nation and the world during the early days of the U.S. space program. Now abandoned save for nesting owls, they are slowly succumbing to the sun, sea, and wind.

At the Cape's Air Force Station, I meet up with my security escort, Bruce Forton, and we pass through the gate and head toward Complex 34, where a Saturn I-B rocket propelled the Apollo 7 capsule into Earth orbit on October 11, 1968. Complex 34 is also the site of the Apollo 1 fire, which took the lives of Gus Grissom, Ed White, and Roger Chaffee on January 27, 1967. A bronze plaque and a wreath donated annually by a local citizen commemorate the tragic event. Most of the launch facility has been dismantled except for the blockhouse and the tunnels connecting it to the pad, as well as the launch ring (part of the base that supported the weight of the rocket), one support building wall, and the flame deflectors.

We arrive just as the bellies of the clouds over the Atlantic begin to burn with an orange light. I photograph what's left of Complex 34 as the sun breaks the horizon and bathes the pad in warm light. I'm using a color print film that's extremely slow—it requires long exposures, from several seconds to several minutes. This gives me a slight but desired shift in color, which, along with the early sun, enhances the pastel hues of the subjects.

>SIGHTINGS<

The early morning reminds me of watching the launches that took place here when I was growing up in the Midwest and would rise before dawn to see the liftoffs on our black-and-white TV. Of course I never imagined that I would someday be roaming around what have become technological relics.

I didn't even realize there was anything left over from this period in space history until I was contacted by an environmental engineer who was cleaning up one of the Cape's unused buildings. He had found some old photographic chemicals and wondered whether I could use them or tell him how to properly dispose of them (I'm a photography instructor at nearby Brevard Community College). When I saw these old launch pads I knew I had to photograph them before they were completely gone. I was amazed at the intricacy of their construction—every pipe, bolt, beam, and block caught my eye. It took a while to persuade the Air Force to give me access to the sites, but I've noted that the personnel here appreciate their history as much as I do.

The images I have taken here, at Marshall Space Flight Center in Alabama, and at Vandenberg Air Force Base in California are part of a collection I have titled "Abandoned in Place"—a phrase stenciled on some of the Cape's structures to indicate that they are no longer being maintained. Many of the metal portions have been removed because over the years, exposure to the salt air has made them dangerously unstable. The site's concrete structures, however, don't deteriorate as quickly. These bunkers, blockhouses, and launch pads were built to withstand tremendous explosions directly above them—they will not come down easily.

Now it is 10:00 a.m. and the light has changed dramatically. A hot white sun blazes down on armadillos grazing on the neatly mowed roadsides. Bruce and I have changed from sweatshirts to T-shirts. The owls have long since taken refuge from the sun and we decide to do the same.

—Roland Miller

GANTRY TRACKS, COMPLEX 34, 1993

WREATH, COMPLEX 34, 1994

LAUNCH RING, COMPLEX 34, 1990

"Please fasten your seat belts..."

NASM

Two new books look at the past, present, and future of commercial aviation.

Turbulent Skies: the History of Commercial Flight *by T.A. Heppenheimer. John Wiley & Sons, 1995. 388 pp., b&w photos, $30.00 (hardcover).*

Airline Odyssey: The Airline Industry's Turbulent Flight Into the Future by *James Ott and Raymond E. Neidl. McGraw-Hill, Inc., 1995. 252 pp., b&w photos, $24.95 (hardcover).*

From the sky, the past and future merge seamlessly into the same horizon, and with the $200 billion commercial aviation industry, as with much else, you can't guess where it is going without examining where it has been. Two excellent new offerings focus on different portions of this same great circle.

T.A. Heppenheimer, an *Air & Space/ Smithsonian* contributor whose previous books include *Colonies in Space* and *Toward Distant Suns*, is an associate fellow of the American Institute of Aeronautics and Astronautics, and *Turbulent Skies* was written as part of the Sloan Technology Series. Yet Heppenheimer is first and foremost a storyteller, with a sharp eye for enlivening—and sometimes astonishing—detail. How many of us knew, for example, that before Charles Lindbergh took history by the hand, his résumé included an airshow act in which he looped the loop while standing on top of his own airplane? Or that an early sketch of a swept wing, on "the airplane of the future," was passed around a dinner table at the Volta Conference sponsored by Benito Mussolini way back in 1935? Or that some supermetals are so sensitive they shatter just falling off a desk, and a line drawn with a Pentel pen would eat through a titanium sheet within 12 hours?

Turbulent Skies traces the trajectory of commercial aviation from its barnstorming ancestry in the wake of the Great War, when much of Europe's transportation system was in ruins and often the only passable roads were in the sky, into the probable future of global positioning satellites and collision-avoidance cockpit controls, the new era of the 777, the possible renaissance of the supersonic transport, the shakeout among the builders, and further post-deregulatory consolidation among carriers. Along the way, Heppenheimer describes the visionaries who designed the aircraft, negotiated routes, forged treaties, built companies, developed the critical mass, and harnessed the unparalleled and unpredictable growth of a technology that evolved entirely within this century. He manages his cavalcade of facts and unforgettable personalities with a ringmaster's versatility and the sure discipline of a scholar.

In comparison, the focus of *Airline Odyssey* is shorter on retrospection, being limited to the era since deregulation. It is somewhat longer and far more detailed in the view it provides of the future, and broader in its treatment of foreign carriers, notably the Russians and Chinese. James Ott is a Eugene Dubois Award-winning reporter for *Aviation Week & Space Technology* who has followed airline deregulation since it went into effect in 1978. His co-author, Raymond Neidl, frequently interprets industry trends on national television and is an airline specialist and managing director with the investment firm of Furman Selz, Inc.

Ott and Neidl are excellent guides through a complex landscape, although, again owing to the nature of their subject matter, their language is more one of numbers: seat miles, union contracts, cash flow, balance sheets, legislative records, Federal Aviation Administration data, airframe design, engine specs. Along the way, they employ a format associated more often with magazines than books, compartmentalizing their chapters with frequent subheads and the use of Q&As. This capsule approach may offer easy reference access, but it frequently impedes narrative flow.

Reading these two books together, I got the sense that the big story in modern aviation is no longer being written by powerful, flamboyant visionaries with splendid, often idiosyncratic imaginations and personal daring. Today, amid continued market fragmentation and the prospect of shake-outs among makers and carriers extending into the next century, even the new developments related to the Airbus A3XX and Boeing's VLCT supertransports or the longer-range revival of the SST all seem somehow less exciting for being re-imagined.

Though the authors of both books

succumbed to the easy metaphor of turbulence, Heppenheimer reminds us that complications in flight can often be salutary; in the wee hours of May 20, 1927, it was the slight instability of his aircraft, more than any other factor, that rescued young Charles Lindbergh from the fatal lure of sleep.

Airline buffs will want to buckle up for two informative reads.

—Frequent contributor Henry Scammell wrote "The Skies, The Limits" (Oct./Nov. 1994), which recounted the founding of the International Civil Aviation Organization and the pivotal Chicago conference of 1944.

IN BRIEF

Fly Past Fly Present: A Celebration of Preserved Aviation, *with an introduction by Walter Boyne. Arms and Armour (Cassell), 1995. 224 pp., color and b&w photos, $29.95 (hardcover).*

This global survey of aircraft restoration applauds the rise of "serious" restoration following too many years when military aircraft, especially those from World War II, were modified and upgraded until their original forms were unrecognizable. Whether aircraft are restored to airworthy condition and flown at airshows or for study in museums, the trend is toward preserving the original. Interesting case histories illuminate the difficulties of restoration projects.

The photographs and captions seem to have been selected in a haphazard fashion, and the absence of an index is regrettable, but the longish essays form chapters that tell a fascinating story about an activity that is, fortunately, growing.

—George C. Larson is the editor of Air & Space/Smithsonian.

Einstein's Greatest Blunder? The Cosmological Constant and Other Fudge Factors in the Physics of the Universe *by Donald Goldsmith. Harvard University Press, 1995. 248 pp., b&w and color photos and illustrations, $22.95 (hardcover).*

Puzzles such as "How large is the universe?" and "Will the universe expand forever?" are at the heart of numerous popular books, newspaper stories, and magazine articles. But scientists use a range of often complex and extremely weird concepts to answer such questions.

As writers struggle to make dark matter, superstrings, quantum gravity, and other subjects intelligible, they often join one of two groups: the plodders and the frantic. The plodders are like visitors to a foreign country who don't know the language but hope they can make themselves understood by talking loudly or slowly. For the frantic, the energy of the writing substitutes for clear explanations. In both cases the reader has as much chance at enlightenment as a little leaguer has of hitting a Nolan Ryan fast ball.

In *Einstein's Greatest Blunder*, Donald Goldsmith, an *Air & Space/Smithsonian* contributor, avoids lurching into the realms of the plodder or the frantic. He writes lucidly, keeps things moving at a good clip, and happily concedes that some of the ideas he writes about may well turn out to be hopelessly wrong. (The book's title in fact derives from a fudge factor that Einstein used to help explain the universe's behavior. Later he lamented that using the fudge factor had been his greatest blunder. Now, as Goldsmith explains, Einstein's blunder might turn out to be right after all.) For those seeking to know more about what scientists today think about the universe and why they think it, this well-illustrated book is an excellent place to start.

—Robert W. Smith, a historian at the National Air and Space Museum, is the author of The Expanding Universe: Astronomy's "Great Debate."

REISSUED

XIII: The Apollo Flight That Failed by *Henry S.F. Cooper Jr. The Johns Hopkins University Press, 1995. 200 pp., $13.00 (paperback).*

One happy result of the success of the movie *Apollo 13* is this reissue of Henry Cooper's 1972 book about the mission. Cooper, whose story about the making of the movie appeared in the June/July 1995 issue of *Air & Space/Smithsonian*, originally wrote this for the *New Yorker*. Those who saw the movie and would like to learn more can turn to this gripping account of a failed mission that many now consider NASA's finest hour.

Edwin Hubble: Mariner of the Cosmos *by Gale E. Christianson. Farrar, Straus & Giroux, 1995. 420 pp., b&w photos, $27.50 (hardcover).*

Edwin Hubble, who lived from 1889 to 1955, was arguably the greatest astronomer of the 20th century. He made fundamental discoveries about the distances to galaxies and their classification into the three basic types: spiral, elliptical, and irregular. But he

earned his greatest fame from his formulation of what astronomers call Hubble's Law: All galaxies save those closest to the Milky Way are receding from us, and the recession velocities (determined from the redshifts in their spectra, which are believed to arise from the Doppler effect) are proportional to the galaxies' distance from us. Hubble first reported this observational fact in a classic paper in 1929, analyzing what in hindsight turned out to be insufficient data. Two years later, however, Hubble and his collaborator, Milton Humason, extended the data to much more distant galaxies, establishing the distance-velocity relationship for good. If (and this is a big if) we in the Milky Way have a representative view of the universe, then galaxies must be receding from one another everywhere, so the entire universe must be expanding, like the skin of an inflating balloon.

Hubble never went this far. As an expert observer he stuck close to the facts and referred to measured redshifts, not measured velocities; he never accepted the Doppler effect as the most likely cause of these redshifts. What made Hubble a great astronomer was not an ability to interpret data but an ability to sense topics of research that would yield important results, as well as an ability to use the world's largest telescopes (first the 100-inch reflector on Mount Wilson, later the 200-inch reflector on Mount Palomar) to observe the most distant galaxies detectable.

This biography, written by a professional historian, provides a detailed, well-written description of Hubble the man, much less about Hubble's astronomical insights, and very little about the astronomy of Hubble's era. Hubble the man turns out to have been (and this was no secret among astronomers) a poseur and a snob, who tremendously exaggerated (to put it politely) his athletic accomplishments, his legal career (he took a degree but never practiced law), and his military service (he went overseas with the Army in World War I, never saw combat but pretended he did, and loved to be addressed as "Major Hubble," especially by those who had held a lower rank). His Rhodes scholarship to Oxford, plus a few Jay Gatsby-like months at Cambridge after the war, turned Hubble into a lifelong Anglophile who affected a British accent. Other astronomers detested him, and the feeling was reciprocated—Hubble and Harlow Shapley, the other great astronomer of the era, maintained a lifelong mutual hostility. In 1924 Hubble married a well-to-do young widow, Grace Leib (she recalled that at their first meeting he "looked like an Olympian, tall, strong, and beautiful, with the shoulders of the Hermes of Praxiteles"); the couple loved to meet the rich and famous, especially the Hollywood stars who lived in the neighborhood of the Carnegie Observatory's headquarters in Pasadena.

None of these human faults made much difference to scientific history, which was forever altered by Hubble's discoveries. Hubble was a master estimator of the *distances* to galaxies, the keystone to Hubble's Law. To measure galaxies' velocities, or at least their redshifts, is a much easier task, requiring only enough light to spread out into a

spectrum. Christianson barely recognizes this, whereas a scientific biography of Hubble would focus on his insight into the distance determinations and their continuing importance. Today Hubble's Law remains at the forefront of astronomical research—precisely because of still-current arguments over the estimated distances to faraway galaxies, which determine the constant of proportionality between distances and redshifts. Hubble would have been properly proud.

—Donald Goldsmith is an astronomy writer in Berkeley, California. His most recent book, Einstein's Greatest Blunder? The Cosmological Constant and Other Fudge Factors in the Physics of the Universe, *is reviewed in this issue.*

VIDEO

As Captain Jean-Luc Picard of "Star Trek: The Next Generation," Patrick Stewart commanded the starship Enterprise *through seven television seasons and one feature film. In "From Here to Infinity" (Paramount Home Video, $14.95), Stewart ventures from science fiction to science fact as the host-narrator on a tour of the known universe. There's nothing new here, but this short and, thanks to Stewart, civilized visit serves as a gentle introduction to the wonders of astronomy—or travel by starship for that matter.* Air & Space/Smithsonian *talked with Stewart about the video.*

Has astronomy been an interest of yours prior to the making of the video?

No, but...a group of fans I have associated with for a number of years presented me with a telescope—quite a serious telescope, I think. The only real home I have is a house in northern England on top of a hill... [and I had the] gift shipped to England, and only last week assembled it and took it outside. I'm going to need an expert to help align it properly. Nevertheless on the first cloudless night, I took it out and succeeded in finding the moon, at about three-quarters, and I'm sorry I was alone because it was an amazing experience. I'd seen the moon in a large observatory, but didn't expect to see so much detail on this telescope, so as soon as I get back

to Yorkshire I look forward to viewing the planets and solar system. The telescope was a most imaginative and thoughtful gift. Didn't know I needed one. Life has been duller without one.

All of us [cast members] have had numerous visits to JPL (I've been twice, once during Voyager, which was extremely interesting for me) and NASA and Houston and Florida. Most thrilling was a Buzz Aldrin visit to the set when he confessed he was a fan. It was delightful when for a few minutes reality overlapped with fantasy. Of course we sat him in the captain's chair; it seemed the only reasonable thing to do.

Your role as narrator in "From Here to Infinity" is more the teacher than the starship captain. Which do you think you would prefer if you were forced to choose?

I have done a certain amount of teaching in my life though of a very different kind, but if it were a straight choice and I were not an actor, I think a spaceship captain is as exciting as it can get. I hope I live long enough to experience a shuttle flight or some form of travel beyond Earth's atmosphere.

If you were able to book time to view the cosmos through the Hubble Space Telescope, what would you look for first among the phenomena you describe in "From Here to Infinity?"

For me, it is the world of our own solar system and our neighboring planets. Once we move beyond, we are into distances and space that is imaginatively hard to grasp. But the worlds of our planets have always been of interest to me, and I suppose it is the planet Mars which is the most compelling and impresses itself most on my imagination. There's probably been more myth, legend, and supposition about it than any other.

What advice might you give as a role model to children and students who see the video and are inspired by astronomy in some way?

I think it would be the same as with any subject, but for me the most important gift is the gift of curiosity, of never settling for what we see or are told, but always being impelled to ask questions and find out more from others or from one's personal research. It is curiosity that sets us above other creatures.

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Shelia Brannum
Business Manager

CREDITS

An Express of the (Near) Future. A lecturer in the school of engineering at Massachusetts Institute of Technology, Frank P. Davidson helped found the Channel Tunnel Study Group in 1957. The group's design for a railway tunnel beneath the English Channel served as the basis for the one adopted by the French and British governments, which was completed in 1994.

Landing Rites. This article was adapted from contributing editor Edwards Park's book *Angels Twenty* (University of Queensland Press, 1994).

Salvation Air Corps. Carl Hoffman says that ever since he flew with the Mission Aviation Fellowship in Irian Jaya, regular commercial air travel has seemed quite unsafe. He lives in Washington, D.C.

A former combat helicopter pilot who served in Vietnam, photographer Geoffrey Clifford lives in Marin County, California.

Further information: MAF's U.S. headquarters: P.O. Box 3202, Redlands, CA 92373. Moody Bible Institute's flight school: Moody Aviation, P.O. Box 429, Municipal Airport, Elizabethton, TN 37644.

5...4...3...2...Abort. Gregory Freiherr is a contributing editor who writes frequently about NASA and space exploration.

When Ships Have Wings. Craig Mellow writes about Russia, with an emphasis on business, from his home in Moscow, where he has been living since 1992. This is his first article for *Air & Space/Smithsonian*.

Auto Pilots. John Grossmann's last story for the magazine reported on start-up airlines ("Flier's Market," Oct./Nov. 1993). He lives in Bucks County, Pennsylvania, and writes for many publications, including *Audubon*, *Men's Health*, *Golf*, and *Sports Illustrated*.

The Road Show. Brian Duff was a Washington, D.C.-based news writer when he joined NASA's public affairs staff in 1963 during the Mercury-Gemini era. After the Gemini program, he directed public affairs activities for NASA's Manned Space Center (now Johnson Space Center) during the Apollo era and, later, agency-wide public affairs during the early shuttle years.

Sightings. Photographer Roland Miller had fleeting thoughts of titling his work "The Launch Pads of Brevard County."

His e-mail address is Miller.R@A1.Brevard.CC.FL.US.

Public Defenders. Austin, Texas freelancer Damond Benningfield writes and produces the syndicated radio program "Star Date."

CALENDAR

December 4–6
American Astronautical Society National Conference and 42nd Annual Meeting. This year's topic is "Beyond the Adventure: The Development and Utilization of Space." Ritz Carlton Hotel, Marina Del Rey, CA. To register, call (703) 866-0020.

December 22
The winter solstice occurs at 3:17 a.m. EST.

January 1
"Sno'Fly: The First Kite Fly of the Year." Sponsored by the Kalamazoo County Parks Department. Kite-making workshop, stunt kite pilots, kite skiers, kite sledders, ice skating. Contests for best decorated line, "most excellent hat," and "awesomest earmuffs." Prairie View Park, Kalamazoo, MI, (616) 383-8778.

Through January 17
A traveling aviation art show sponsored by the Air Force Museum in Dayton, Ohio, and featuring works by the British Guild of Aviation Artists. Subjects include early balloon flights, World War I and II, and modern aircraft. Gabriele Art Gallery, Frenchtown, NJ, (908) 996-6011.

January 21
Open Cockpit Sunday. Approximately 15 aircraft open for inspection, including World War II and modern fighters, bombers, and helicopters. New England Air Museum, Bradley International Airport, Windsor Locks, CT, (203) 623-3305.

January 30
PBS stations will air "B-29 Frozen in Time," a *Nova* documentary about an expedition to recover a B-29 trapped in the ice in Greenland. (The film was made before the B-29 was destroyed in a fire after being recovered.) Check local listings for times.

February 9
Air Traffic Control Association Symposium. Hyatt Regency Crystal City Hotel, Arlington, VA, (703) 522-5717.

"The Satellite Sky" Update/51

These regular updates to "The Satellite Sky" chart will enable readers to keep their charts up to date. Additions can be clipped and affixed to the chart at the appropriate altitude.

New launches

90 to 300 MILES

- Soyuz TM-22 9-3-95 TT
- Resurs F-2 9-26-95 PL
- Cosmos 2320 9-29-95 TT
- Progress M-29 10-8-95 TT

300 to 630 MILES

- Sich-1 8-31-95 PL
- Fasat 1 8-31-95 PL
- Cosmos 2321 10-6-95 PL

21,750 to 22,370 MILES

- Luch 1-2 10-11-95 TT
- Koreasat 8-5-95 CAC
- JCSat 3 8-29-95 CAC
- PanAmSat 4 8-3-95 KOU
- N-Star 1 8-29-95 KOU
- Telstar 402R 9-24-95 KOU
- Cosmos 2319 8-30-95 TT

Deletions

90 to 300 MILES

Cosmos 2314 down 9-6-95

Progress M-28 down 9-4-95

Inoperative but still in orbit

6,200 to 13,700 MILES

Cosmos 2204

Launched but not in orbit

90 to 300 MILES

STS-69 U.S. research	9-7-95	down 9-18-95

DATA: SAUNDERS KRAMER

FORECAST

In the Wings...

The Longest Line. In the standard pattern of aeronautical progress, aircraft that satisfy one generation retire, outdone by the next generation's technology. It ain't necessarily so. After combing corporate files for manufacturers that kept their production lines going (and going and going), *Air & Space/Smithsonian* found the top 10 airplanes in continuous production. You won't believe what made the list...and what didn't.

Dresden's Secret. In 1961, the East German politburo dissolved its aircraft industry. Twenty-five thousand workers were dispersed to other jobs, prototypes were dismantled, and technical files were buried in Moscow. For the next 30 years the story of the Dresden Aircraft Factory's four-engine jetliner lay hidden behind the Iron Curtain.

The First Moon Race. The United States beat the Soviet Union to the moon with the Apollo program, but NASA was definitely playing catch-up.

Contrabandistas. In the 1970s, the Texas border was an aeronautical Wild West, with outlaw pilots flying DC-3s packed with TVs, stereos, and other electronics into Mexico. The flying was routine, as long as they stayed away from the Mexican customs police.

I Can See Clearly Now. Astronomers have traditionally gone to great heights to avoid the atmosphere. Now using adaptive optics technology developed for the Strategic Defense Initiative, ground-based observatories can compensate for the atmosphere's interference with visible light. The techniques range in complexity, but the best may be able to image planets orbiting other stars.

JOHN HEINLY

Public Defenders

At the height of the cold war, school teachers taught children how to duck and cover. Military strategists brooded over Mutual Assured Destruction. And batteries of Nike missiles stood guard over major U.S. cities, their radar dishes scanning the heavens for Soviet missiles and bombers.

"When I was young, there was a Nike base right by my home outside Philadelphia," says Terrie Cornell, registrar at the U.S. Army Air Defense Artillery Museum at Fort Bliss, Texas. "Every time we drove by, I looked at those missiles with N-I-K-E painted right down the side."

Today, the museum, just outside El Paso, is one of the few places where Americans can still see the sleek black-and-white missiles. Two of them, stripped of their engines, flank the front door. Inside the mustard-colored building, which looks like a posh VFW hall, exhibits recount the history of air defense weaponry, from rifles to anti-aircraft guns to precision guided missiles. The focus is on U.S. Army technology, though weapons from other nations are included.

The first air defense units in this country were organized in 1917. The job fell to the Coast Artillery Corps, the service branch responsible for fending off invading ships and the only one with experience in firing at moving targets. At the time the U.S. military had not developed weaponry specifically designed for use against aircraft. The museum displays two machine guns, the Lewis and the Hotchkiss, that U.S. servicemen used in France during World War I to fight off enemy airplanes.

As aircraft evolved, so did the weaponry used against them. By the second world war, anti-aircraft weapons were guarding U.S. aircraft carriers against kamikaze pilots, staving off massive bombardment of the captured bridge at Remagen, Germany, and protecting London from Germany's V-1 "buzz bombs." Inside a display case at the museum, a bent propeller blade from a Focke-Wulf Fw 190 provides dramatic evidence of the weapons' effectiveness. Two U.S. Army battalions, the Third Armored Division's 126th and 451st, firing machine guns and cannon at German aircraft over France, Belgium, and Germany, recorded their victories on the blade. On the left side, 19 small swastikas mark confirmed kills; on the right, 18 aircraft silhouettes indicate probables.

Nearby, a 40mm Bofors gun crouches behind rows of sandbags, with camouflage netting that once concealed it from Japanese aircraft. The most widely used anti-aircraft gun of World War II, the Bofors was capable of firing 120 rounds a minute. Columbia Pictures restored the museum's gun for the movie *1941*. More artifacts from World War II and later years are displayed in an outdoor "weapons park," including a German 88mm anti-aircraft gun, bright orange target drones used by the U.S. Army for gunnery training, and a V-2 rocket. Developed by Wernher von Braun and his team in wartime Germany, V-2s were the world's first long-range ballistic missiles.

U.S. Army Air Defense Artillery Museum, Building 5000, Pleasonton Road, Ft. Bliss, TX 79916. Phone (915) 568-5412. Open 9 a.m.–4:30 p.m. daily except New Year's Day, Easter, Thanksgiving, and Christmas. Free admission.

Photographs at the museum show U.S. anti-aircraft weaponry becoming increasingly complex during the cold war. One example, the Stratosphere Gun, was the largest, heaviest, and most powerful anti-aircraft gun the U.S. Army ever built. The 31-ton monster could fire 50-pound projectiles 11 miles high. It was deployed in and around U.S. cities during the early 1950s but was rendered obsolete by high-altitude intercontinental ballistic missiles.

Because of its cold war expertise, the museum serves as a source of information for those unfamiliar with the anxieties of the era. "Most of the people who call are young and don't have a clue about the cold war or the Cuban Missile Crisis," says Terrie Cornell. "It seems so archaic; it's hard for them to understand that we could build missile sites around our cities."

The U.S. Army's last attempt to provide a continent-wide defense against an ICBM attack was an extraordinary invention called Safeguard. Dioramas at the museum depict a tranquil scene: a large coastal city in the background, ocean extending into the distance, and in the foreground what looks like a gopher colony, with dozens of silos linked by a subterranean maze. Early plans called for 12 sites scattered around the United States, each with its own underground power and water supplies and dozens of missiles. Phased-array radar systems would detect incoming ballistic missiles at ranges of more than 1,000 miles. If the ICBMs were still outside the atmosphere, operators would fire three-stage Spartan interceptor missiles equipped with nuclear warheads. The final line of defense was the short-range Sprint, a squat, inelegant missile that streaked through the atmosphere so fast that friction heated its skin to a higher temperature than its rocket engines (a Sprint sits behind the museum, an outcast among its streamlined cousins).

The first Safeguard site, in North Dakota, was declared operational in October 1974, but only a month later the SALT II arms control treaty handed continental air defense over to the Navy and Air Force, and the site was closed.

The museum gives visitors a historic perspective on their surroundings: Fort Bliss is the home of the Air Defense Command and Air Defense School. Here, Army personnel learn how to operate such anti-aircraft theater weapons as the Hawk missile, the "man portable" Stinger missile system, and the Patriot, which was used against the Iraqis' Scuds in the Gulf war. Though no longer charged with continental defense, the Army is still in the business of ensuring that what goes up will come down—quickly.

—Damond Benningfield

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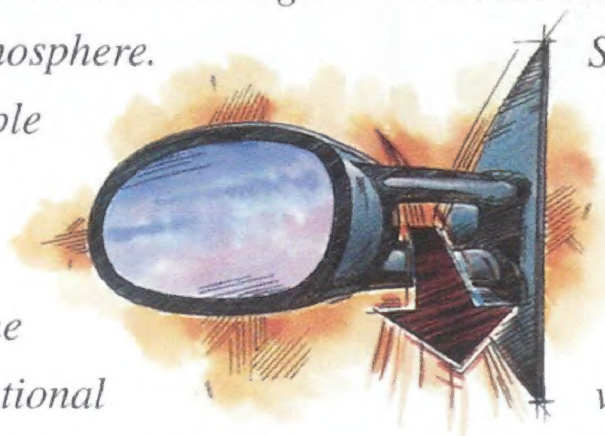
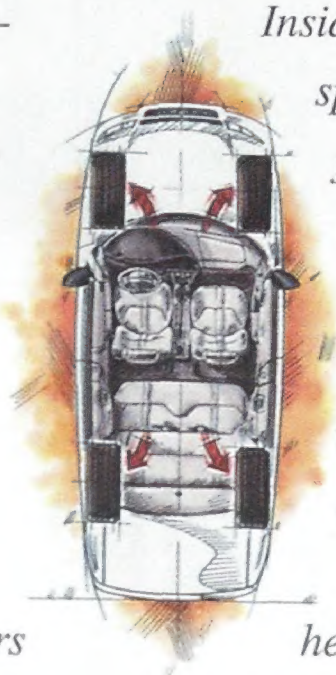


The lines are round, soft, wedge-like. Its wheels-to-the-corners stance helps give Stratus remarkable handling and stability. The lowered cowl provides superb visibility and aerodynamics. And the dual pedestal-mounted side mirrors channel airflow so deftly, they even manage to reroute the rain for better side window visibility.



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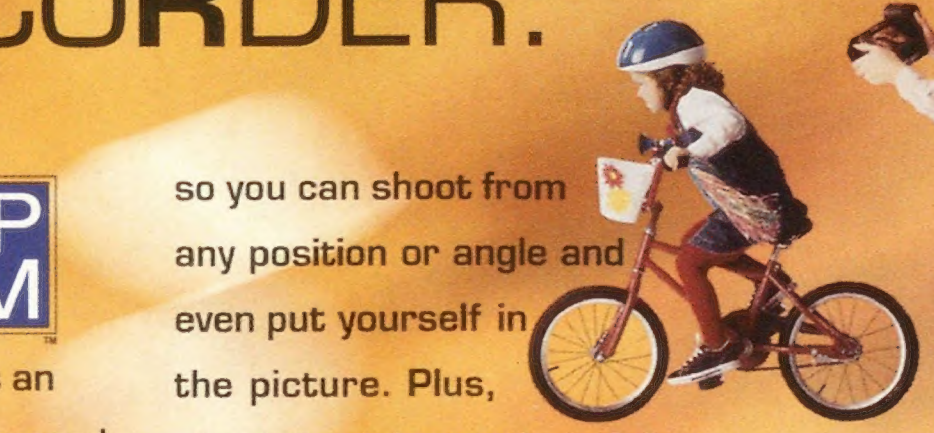

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